POWER PLANT ENGINEERING

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Power for the Atlantic Refining Co.

DESCRIBING CONSTRUCTION AND METHODS OF OPERATION OF ONE OF SEVENTEEN POWER PLANTS SERVING THE LARGEST OIL REFINERY IN PENNSYLVANIA

ON THE OUTSKIRTS of Philadelphia, at Point Breeze, there is located a vast industrial institution as impressive in its external aspect as it is important as a factor in modern civilization. As far as the observer's eye can reach, there stretches forth on all sides a view teeming with the most intense industrial activity possible for one to imagine—a view to inspire the poet as well as the engineer; for beneath the physical layout of this vast plant lies hidden the power of the engineer. Just as the rich, dark oil which is refined there represents the accumulated solar energy of prehistoric ages, so does the plant as a whole represent the accumulated mental and physical energy of untold years of effort on the part of the engineers and chemists instrumental in the development of the oil industry.

This plant, which is that of the Atlantic Refining Co., is the largest oil refinery in Pennsylvania. It comprises some 640 acres of ground area, all of which is literally covered with one great aggregation of tanks, stills, pump houses, etc., and connected by an intricate network of piping that fairly makes one's head whirl.

For its operation, this enormous refining plant requires the continuous operation of a number of separate power plants or boiler houses. These range in size all the way from 500 to 1000 hp. in the case of the old return tubular plants to as much as 8000 hp. for the more modern ones. Taken together, they have an aggregate capacity of approximately 45,000 boiler horsepower. If conditions demand, the above plants are easily capable of supplying 65,000 boiler horsepower.

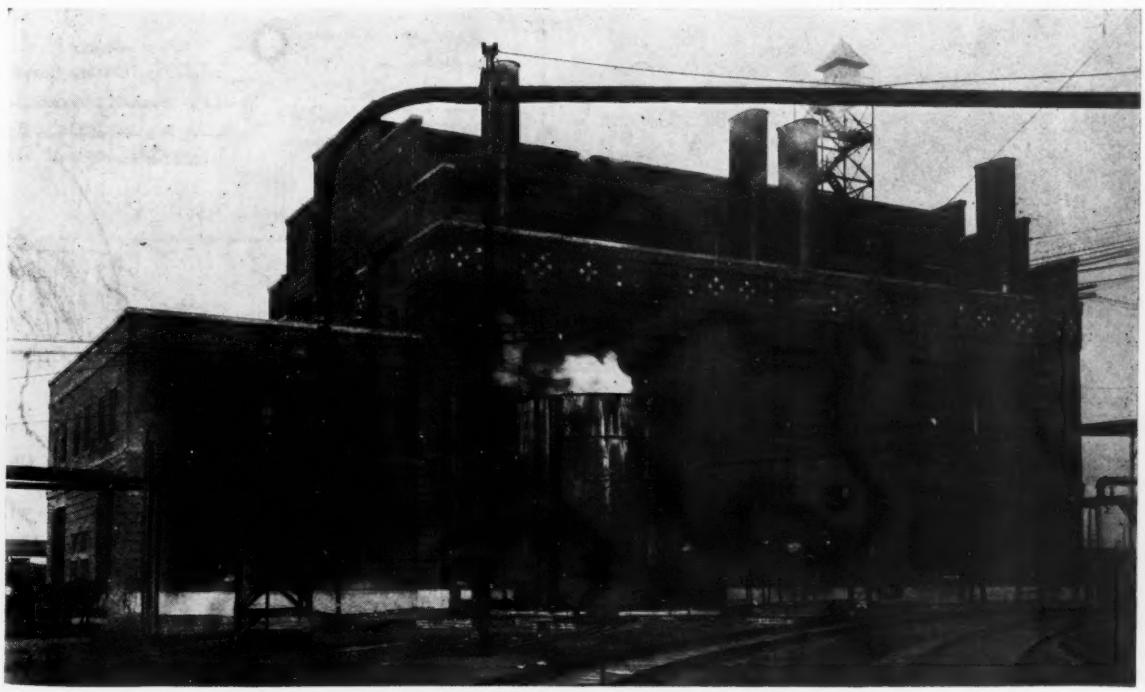


FIG. 1. EXTERIOR VIEW OF NO. 18 BOILER HOUSE

As is to be expected in the case of a plant of this character, the various boiler houses vary considerably

in design and type of equipment, according to their age and the character of service required of them. They were built as the refinery grew in size and naturally the later ones are more modern in design than those which were built at first. While some of the earliest plants have been discarded, there are today 17 separate boiler plants in actual operation, this figure including a number of waste heat installations. These supply the refinery with steam, water, air, and electricity for all purposes, and their operation is an important, in fact, an indispensable factor in the process of refining oil. With the exception of a comparatively small amount used for the generation of electricity, most of the steam produced is used throughout the refinery for operating thousands of pumps, for heating oil tanks and for other process work.

Hundreds of miles of overhead and underground piping throughout the plant distribute power in all its forms to the various points of consumption. Electricity

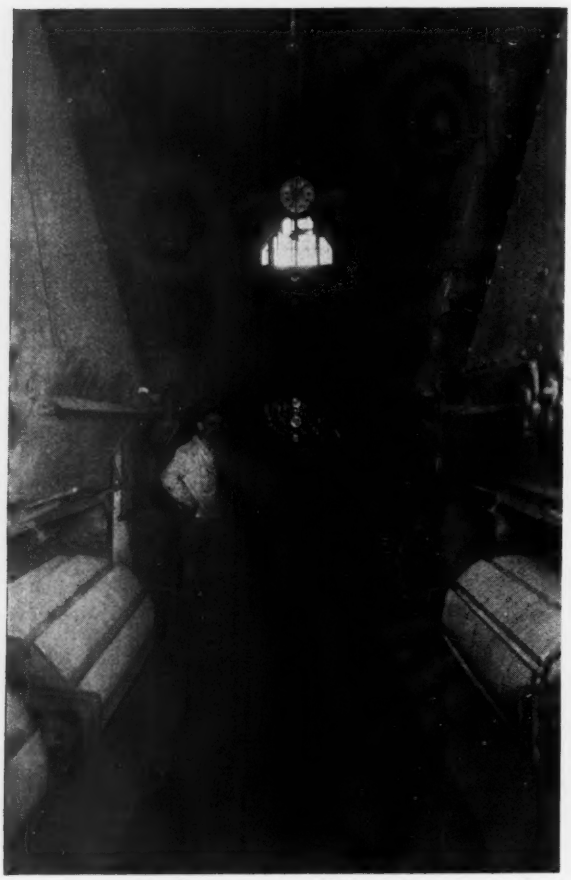


FIG. 2. VIEW OF BOILER ROOM

is distributed from a number of turbo-generating plants installed in connection with the boiler houses at both 2200 and 440 v.

Of the 17 boiler plants, the latest, and also perhaps, the most efficient, is the No. 18 boiler house, which has a rated boiler capacity of a little in excess of 8000 hp. This plant was completed 3 yr. ago, and is of the most modern construction. It is built of brick, steel and concrete, is 186 ft. long, 100 ft. wide and 75 ft. in height. The exterior is faced entirely with red pressed brick, ornamented with square white tile blocks as shown in the accompanying photograph.

Steam Generating Equipment

Steam is generated in eight, Stirling four-pass boilers, rated at 1003 hp. each and built for a working pressure of 180 lb. There are three steam drums, 42 in. in diameter by 23 ft., 11⅞ in. long, and one mud drum 48 in. in diameter by 21 ft., 5½ in. long. The drums are connected by 758—3¼-in. tubes. Each boiler has a width of 23 ft., is 21 ft., 6 in. in depth and has a total heating surface of 10,034 sq. ft.

Fittings consist of six, 4-in. Ashton safety valves set to blow at 180 lb., two 2½-in. feed water stop valves, two 2½-in. check valves, two 2½-in. Homestead cocks and two 2½-in. Simplex blowdown valves.

To prevent, or at least to reduce trouble due to priming, a so-called dry steam drum has been installed on top of each of the eight Stirling boilers. In the interior of this dry steam drum is installed a separator made of boiler plate and angle iron. This together with a well designed trap system has resulted in removing some of the moisture.

The boilers are all provided with Sturtevant cast-iron economizers installed in the rear as shown in the cross section of the boiler house, Fig. 4. Each economizer is constructed of 288—12-ft. pipes, 4⅝ in. in diameter,

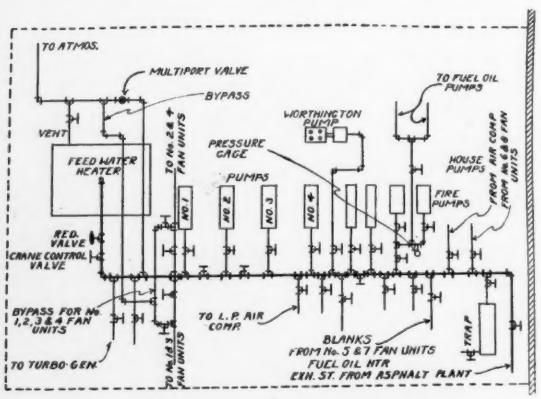


FIG. 3. DIAGRAM OF AUXILIARY EXHAUST LINE

arranged in 24 sections of 12 tubes each. The total heating surface is 4610 sq. ft. and the water capacity is 22,413 lb. The economizers were built for use with 1000-hp. Stirling boilers to operate at a maximum of 200 per cent rating. The ratio of economizer heating surface to the boiler heating surface is 0.455.

Although oil is fired at a number of the boiler houses throughout the refinery, at No. 18 (the plant under consideration) only coal is fired at present. Figure 7 shows installation of oil burners during a period when this house was oil fired. Each of the boilers described above is fitted with two Coxe, type B, chain grate stokers, each having an effective grate area of 131 sq. ft. or 262 sq. ft. of grate surface for each boiler. Each stoker is driven through a worm gear by a 5-hp. rated variable speed induction motor mounted, one on each side of the boiler, and by which the speed of the stokers may be varied anywhere from 20 to 40 ft. per hr.

The stokers are installed in a type of dutch oven

furnace fitted with Detrick suspended arches, the details of which may be seen by referring to Fig. 5. The total furnace volume of each boiler is 1345 cu. ft.

The interiors of the furnaces are lined with "Woodland" fire brick except the first course which is of Carborundum, while the outside walls are treated with Evertight compound. Diamond soot blowers are installed on all boilers, and Copes feed water regulators serve to maintain, automatically, correct water level under varying conditions of load.

All boilers are equipped with a system of balanced draft apparatus, devised by the operating force.

purposes. The four centrifugal pumps are 3-stage, horizontal type, De Laval pumps with a capacity of 800 g.p.m. under a 580-ft. head when operating at 2300 r.p.m. They are driven by 200-hp. De Laval steam turbines direct connected to the impeller shaft through semi-flexible couplings.

The feed pumps take suction direct from a Cochrane feed water heater, having an ultimate capacity of 600,000 lb. per hr. The heater utilizes exhaust steam from the auxiliaries and is equipped with a Cochrane V-notch meter and recorder.

There are two separate feed lines supplying the

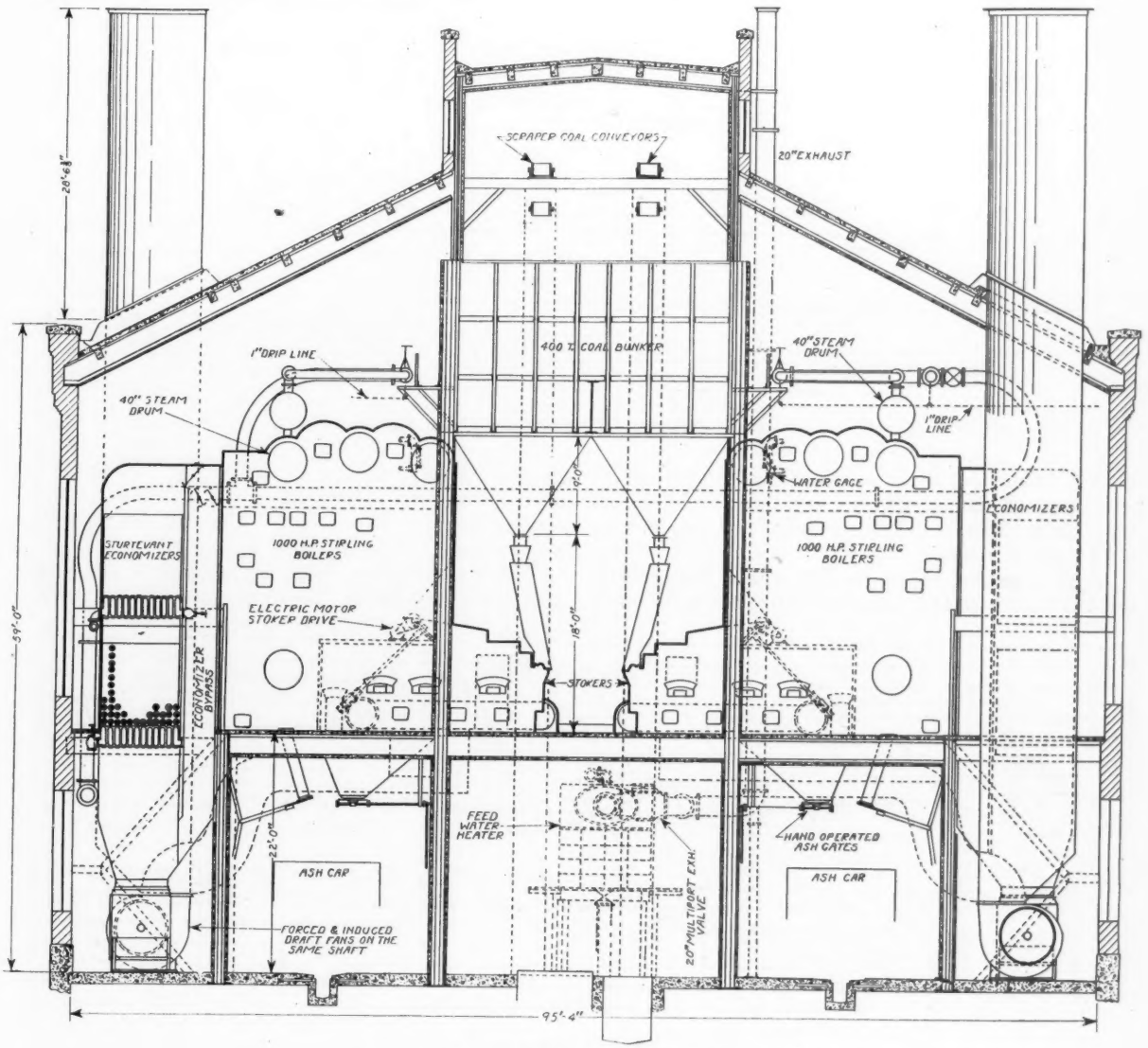


FIG. 4. SECTION THROUGH BOILER HOUSE

Feed Water

Boiler feed water is taken through an 8-in. line from a 110,000-gal. storage tank located on the outside of the building, and is delivered to the main feed water header by the boiler feed pumps. There are five feed pumps, four of which are of the centrifugal type for regular operation, while the remaining one is a Worthington duplex steam driven unit provided for emergency boilers; one, a main feed line system and the other an auxiliary system. The latter is used only under emergency conditions, or for test purposes.

In addition to the boiler feed pumps already mentioned, there are located in the basement two fire pumps and two service pumps. The fire pumps are rated at 1000 gal. per min. each. These pumps are Worthington Type B, 18 by 10 by 12 in., 70 r.p.m., 4 good 1⅛-in.

smooth streams. The service pumps are steam driven, made by the National Transit Co., of the duplex type.

Forced and Induced Draft

Forced draft is supplied to the furnaces by eight Sturtevant fans, one for each boiler. These fans are capable of delivering 35,000 cu. ft. of air per min. at 65 deg. F. under a static pressure of 3½ in. Each boiler, economizer, together with forced and induced draft fans form a complete unit, there being no common air duct.

Five of the eight forced and induced draft units are equipped with dual systems of drive; that is, there is a 100-hp. electric motor on one end of the shaft while a Terry turbine is geared to the opposite end. The remaining units are steam driven. Although the primary object of installing dual drives on some of these units was to provide a simple method of maintaining a proper heat balance, the dual system also furnishes an excellent alternative method of drive in case of trouble with either of the two prime movers.

In the design of the fan installation, the forced and

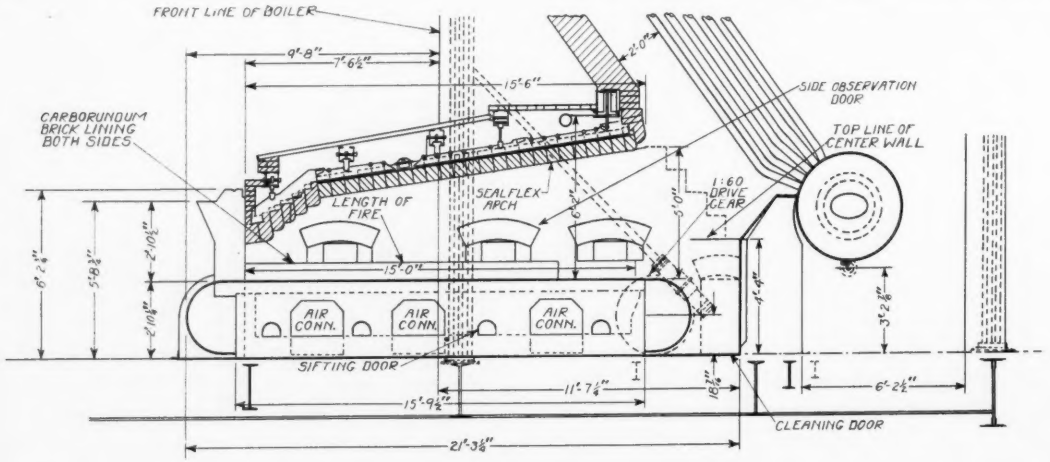


FIG. 5. DETAILS OF FURNACE AND STOKER

The induced draft fans, which serve to draw the gases through the economizers, are rated at 70,000 cu. ft. of air per min. at a temperature of 500 deg. F. with a 3-in. static suction.

A peculiar feature in connection with the arrangement of the forced and induced draft fan installation, is the fact that both the forced and induced draft fan for each boiler are driven by a single prime mover and are mounted on the same shaft. Each set of two fans is installed in the basement, side by side, directly connected and operated either directly by an electric motor or through reduction gears by a steam turbine. Both forced and induced draft fans are built to operate at 410 r.p.m., the forced draft fans requiring 31 b.hp. and the induced draft fans 49 b.hp. or a total of 80 b.hp.

induced draft fans were selected so as to operate in conjunction with each other. This arrangement is simple, compact, and although hand regulated, has proved successful in operation.

Since the hot exit gases are brought in close proximity with the incoming air to the forced draft blowers, there is no doubt some heat reclaimed, although the actual amount may be negligible.

A steel stack is provided for each boiler. These, as may be noted from the photograph, Fig. 1, are short, and only serve to carry away the gases of combustion, since the induced draft fans meet all draft requirements.

1922
No. 18 BOILER HOUSE

WEEK ENDING	AVERAGE B.H.P.	LB. WATER PER HOUR	LB. COAL PER HOUR	LB. WATER PER LB. COAL (ACTUAL)	OVERALL EFFICIENCY	B.T.U. LB. OF COAL AS FIRED	PERCENT ASH IN REFUSE	LB. COAL PER H.P. HOUR	KIND OF COAL - PERCENT			
									No. 2	No. 3	No. 4	No. 5
1-6	13355	400630	59760	6.70	72.9	8911	88.13	4.48	8.7	60.3	20.7	10.3
1-13	12407	372210	52775	7.05	64.6	10593	88.79	4.25	10.5	68.6	20.2	10.7
1-20	12286	368580	52880	6.97	63.5	10674	91.40	4.30	8.4	53.5	25.8	12.5
1-27	12890		54633	7.07	64	10688	75.18		8.5		19.4	11.8
AVERAGE	12			6.95			85.82		9.0		21.5	11.3
	9194			6.49				4.63				
AVERAGE	9627	288	620	6.49	62.2		77.84	4.63	10.6	53.0	24.8	11.6
5-5	9583	287490	44765	6.41	60.5	10234	64.10	4.48	7.9	53.3	32	9.8
5-12	8955	268650	41320	6.50	58.4	10664	76.10	4.61	8.4	53.4	25.4	12.7
5-19	8732	261960	40040	6.54	65.5	9689		4.59	11.3	48.9	25.8	14.0
5-26	8631	259530	35573	7.3	69.4	10058	73.80	4.11	10.1	51.3	29.1	9.5
AVERAGE	8980	269400	40430	6.69	63.4	10175	75.57	4.5	9.4	51.0	28.1	11.5

FIG. 6. WEEKLY EFFICIENCY RECORD

A steel stack is provided for each boiler. These, as may be noted from the photograph, Fig. 1, are short, and only serve to carry away the gases of combustion, since the induced draft fans meet all draft requirements.

Coal and Ash Handling

Coal is delivered from railroad cars, into either of

two track hoppers, one under each side of the boiler room. Under each of these hoppers is installed an apron conveyor which delivers coal from the hoppers into a bucket conveyor. These bucket conveyors travel upwards to the top of the boiler house and deliver the coal to overhead bunkers above the firing aisle. Each conveyor has a capacity of 60 T. per hr., which gives the plant a total capacity of 120 T. per hr. The coal handling equipment is all of Beaumont manufacture and is operated by electric motors.

The overhead bunkers consist of four steel bins each having a capacity of 13,392 cu. ft. or about 400 T. of the kind of coal usually burned. The latter is very fine and when wet, usually runs about 60 lb. per cu. ft.

Coal from the overhead bunkers is fed to the stoker hoppers through individual chutes equipped with chain operated coal valves. The thickness of the firing bed can be regulated by means of a handwheel at the side of the stoker hopper which varies the opening through which the coal passes when entering the furnace. An indicator attached to this mechanism shows the thickness of the fuel bed, directly in inches.

Ashes are dumped directly from the hoppers under the ashpits of the boilers into specially constructed ash cars. These cars consist of a large steel hopper mounted

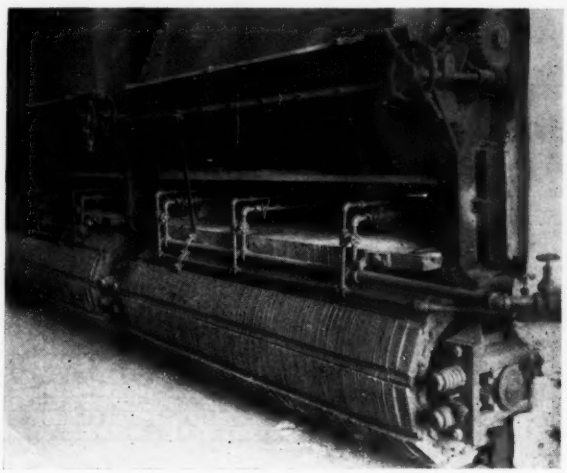


FIG. 7. PHOTOGRAPH SHOWING INSTALLATION OF OIL BURNERS DURING A PERIOD WHEN THIS HOUSE WAS OIL FIRED

on a short railroad flat car, with a suitable gate at the bottom for dumping the ashes. When filled these cars are hauled out into the yard over a track hopper. Ashes discharged into the track hopper are carried by a skip hoist to the top of and delivered into a large steel, brick lined, ash storage bin. From the bottom of this bin, ash is delivered to trucks for removal.

While the above described ash handling arrangement may seem to the readers to be unnecessarily complicated, it actually is not, and requires very little labor for its operation. The skip hoist is electrically driven and is entirely automatic in operation. Pressing an electric button, starts the skip hoist, delivers the ashes into the storage bin and returns the skip hoist bucket to its starting point ready to receive another load of ashes.

The coal which is usually burned at this plant runs a trifle over 10,000 B.t.u. per pound and is very fine in size. The weekly efficiency record shown in Fig. 6 shows some of its qualities. At the present time, however, coke breeze is being tried out under the boilers and although some difficulty was experienced with this type of fuel at first, very satisfactory results are now being obtained.

Coal is stored in the yard close to the boiler house where 30,000 T. of coal can be stored under ordinary conditions.

To provide against difficulty in unloading coal in winter when the coal is heavily frozen in the cars, a

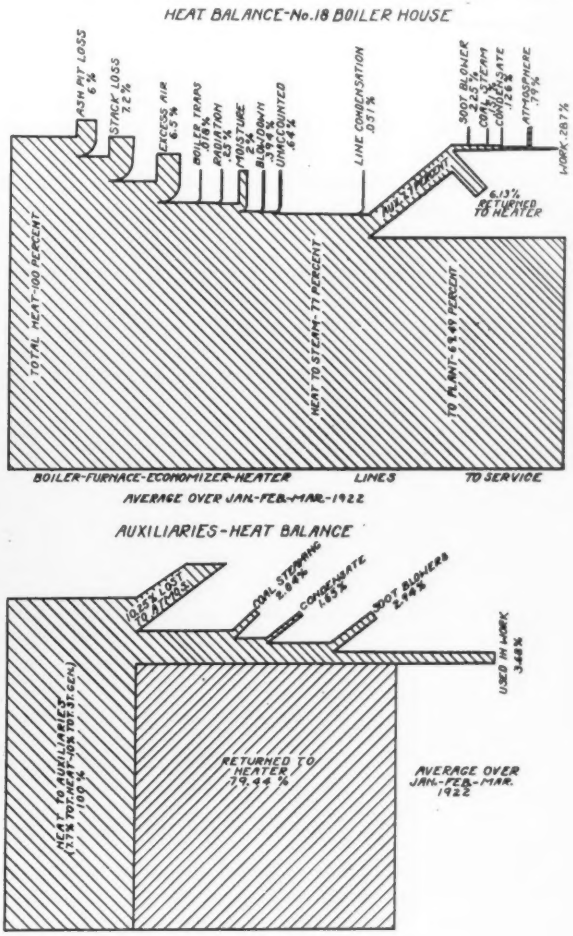


FIG. 8. HEAT BALANCE DIAGRAMS

steaming pipe system is installed adjacent to the two railroad tracks entering the boiler house. Coal is steamed by thrusting 7-ft. lengths of pipe into the car, the steam flowing through in the meantime. This arrangement has been found highly effective and economical in cost of operation.

Instrument Equipment

Each boiler is equipped with the following instruments:

One General Electric Co. recording flow meter (nozzle plug type).

One Uehling recording CO_2 meter.

One Foxboro recording thermometer (last pass temperature).

One recording thermometer (feed water temperature, between economizer and boiler).

Indicating draft gages (one forced draft blast, and a Hayes differential draft gage over fire).

Two thermo-couples, located in the path of gases before and after the economizer.

In addition to the above, permanent draft connections are installed on each boiler in locations as follows: Under and over the fire, last pass, after economizer and in the stack. These connections are brought to a central point where tests may be made at any time.

Each of the four main steam lines leaving the boiler house, has installed on it an individual recording General Electric Co. steam flow meter. A separate meter is installed on the house auxiliary line, for the purpose of measuring steam to the house auxiliaries.

The quality of the steam is observed continually by means of recording throttling calorimeters installed on the main feeders to the service headers.

The feed water heater is equipped with a V-notch meter, and with recording thermometers on the incoming and discharge lines.

lar jobs, and that routine is strictly maintained. The men are held directly responsible for their work.

Records are kept and interpreted with regularity and the results applied to operation. Costs are analyzed and studied.

Routine of Repairs and Maintenance

As stated elsewhere in this article, there are eight boilers, each an entirely separate unit. It is the practice to drop one of these units for repairs and cleaning each week. In other words, a boiler is in service for seven weeks and is cleaned and repaired during the eighth week. With this method, there are at all times seven boilers in service. While this practice may seem to be over-doing a good thing, the operating force feels that the results obtained fully justify the cost.

The boiler that is to be cleaned is taken off the line on Saturday and on Monday morning has cooled sufficiently to allow the men to proceed with the work of cleaning and repair.

Two men who constitute a scaling crew turbine out all the tubes, and remove all scale from the drums to

A

No. 18 BOILER HOUSE

H.P. BOILERS	1921 JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	AVER.	1922 JAN.	FEB	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1	1738	1599	1713	1749	1626	1780	1701	1750	1492	1601	1574	1530							
2	1666	1820	1787	1780	1616	1797	1744	1675	1535	1603	1380	1380							
3	1871	1789	16																
4	1774	1782	15																
5	1718	1683	18																
6	1722	1691	18																
7	1817	1931	15																
8	1461	1442	1																
TOTAL H.P.	13197	13758	14																
ACTUAL B.H.P. DEVELOPED	11239	11360	11																
H.P. BY V-NOTCH METER	11610	10952	10																
AMT. WHICH FLOW METERS EXCEED V-NOTCH	-351	-858	-1																
AVERAGE TOTAL FLOW ON LINES	10047	10190	10																
TEMP. OF WATER TO HEATER	139	127	1																
" " " FROM "	209	211	2																
" " " " ECON.	278	282	2																
TEMP. STACK GASES (BEFORE ECON.)	611	622	6																
" " " AFTER "	414	429	4																
" " PERCENT CO_2	9.6	10.0	1																
PERCENT RATING	181	179	1																

B

VARIABLES	YEARS 1920	1921	WEEKS OF YEAR-1922 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
B.T.U. OF COAL	9898	9704	8911	10573	10679	10688	10153	10135	10148	9955	10631	11337	9801	10881	9775	10231	10417	10023	9830
AVER. LB. PER HP. COAL USED	50205	51876	59760	52775	52880	54653	54533	53440	49500	51827	50473	47013	48040	47700	49326	51200	49926	49787	49373
AVER. LINE OUTPUT (B.H.P.)	8225	10542	11812	11031	11288	11854	11505	10915	10676	11365	11460	11663	10692	9538	9377	9419	8232	8351	8120
TOT. AVER. LOAD ON HTR.	277511	382260	460650	372210	366580	366700	373490	360000	380000	390000	385000	370050	333780	302728	309810	320640	220478	297740	280000
DEG. F. RISE THROUGH HTR.	84	83	118	108	96	99	96	94	92	94	93	42	89	93	93	94	92	80	72
TOT. AV. ST. CONSUMP. OF AUX.	23280	2910	36130	38350	51930	56850	53910	47190	42960	46380	46620	48090	42480	37530	37260	38910	32850	32820	32000
LAST PASS TEMP.	513	617	597	635	690	630	625	610	650	690	710	680	646	628	607	623	618	618	615
STACK GAS TEMP.	373	417	420	435	440	420	425	410	500	490	500	470	436	418	400	420	400	410	400
AVER. PERCENT CO_2	9	8.7	9	9.4	9.2	9.4	9.5	10.2	9.6	9.4	9.8	10.3	10	9.5	9.5	9.4	9.9	9.4	10
COMBUSTIBLE IN REFUSE %	22.4	23.8	11.87	11.21	8.60	24.42	20.54	10.72	9.34	13.8	33.12	36.80	13.88	20.34	14.42	10	25	26	21
PERCENT ASH IN COAL	21.3	22.4	20	21.95	20.2	20.10	21.0	20.10	20.6	19.8	20	19.1	25.3	25.00	23	27	20	25	22
HEAT BALANCE																			
HEAT TO STEAM	60	69	67	71.	67	70	70	68	70	74	71.5	72	76	68	66	60	66	65	66.5
LOSS TO AUX.	2	3	2.2	3.7	3.5	4.5	3.5	3.2	2.7	3.0	3.10	5	2	1.2	3.5	2.6	4	3.3	3.9
" " STACK	7	7	7.5	7.5	7.6	7	7	6.5	8.5	8.5	8.5	6	6.5	7	6.5	7	6.5	7	6.5
" " EXCESS AIR	11	8	8.0	6	6.5	6	5.5	5.3	7	8.5	6.5	6	6.0	6.0	7	7.4	5.5	6	5.0
" " ASH PIT	12	10	5	3.5	3	7	7	5	3	4	8	8	4.5	8	5	4	9	11.7	7.9
LOSS TO MOIST. CONST. AT 2%	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
SUM OF LOSSES	94	99	89.7	93.7	89.6	96.5	95	90	93.2	100	98.6	99	97	92.2	90.0	83	93	95	92
BAL. & UNACCT. FOR LOSSES	6%	1%	6.3%	6.3%	10.4%	3.5%	5%	10%	6.8%	0%	4%	1%	3%	7.8	10	17	7	5	8

FIG. 9. A. GENERAL RECORD SHEET. B. HALF YEARLY BALANCE SHEET

Besides the instruments listed above, a number of other recording and indicating pressure and temperature gages are installed in various portions of the plant as needed.

The operating engineers have in their possession an Orsat apparatus, mercury and glass thermometers, test pressure gages, test draft gages, etc., and sufficient simple equipment to do all ordinary routine investigating.

Operation

The foregoing has been principally devoted to a description of the constructional features of this plant. The operating features of a station of this type, however, are of considerable interest and are of sufficient importance to warrant detailed treatment.

The operating force at the plant feel very strongly that eternal vigilance is the price of efficiency and that in the multitude of detail that must be attended to, routine is the only salvation. Every possible effort has been made to establish routine where men have particu-

insure clean heating surfaces. Records are carefully kept of the total scale deposit and also of the number of pounds of scale per 1000 b. hp.-hr. The latter record serves as an index to conditions.

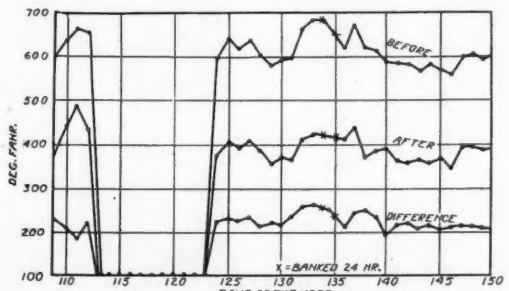
One man known as the "external heating surface man" has for his entire duty, the work of cleaning and polishing the 10,000 sq. ft. of external boiler heating surface and the 4600 sq. ft. of economizer surface. Marked success has been obtained by washing down the external heating surface of both boilers and economizers with water. If reasonable care is exercised in doing this, no damage to the brickwork or setting will result. The loose dust drops into the ashpit and combustion chamber while the hard scale due to its different coefficient of expansion from that of the metal of the tubes, mostly falls off. The small amount that remains can easily be scraped off.

The stoker and arches are thoroughly inspected, and all necessary repairs are made by a separate crew. In the meantime, a machinist inspects the fan units, feed

pumps and associated equipment, and makes such repairs as may be necessary. All piping, water columns, blowoff valves and other fittings are likewise inspected and put in good shape for the run by the steamfitter.

Another man, known as the "boiler setting man" whose entire job it is to inspect and caulk up all possible leaks around the boiler and economizer settings, next goes over the boiler. Due to the high negative pressures employed in the economizer (ranging from 2 to 3 in. suction) particular difficulty is experienced in keeping the economizer settings tight. It is, therefore, deemed necessary to exercise particular vigilance against high air infiltration and consequent heat losses.

It is also the practice to clean internally by means of rotary tube cleaners, one half of the economizer dur-



	APRIL-1922										MAY-1922									
	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	10
BEFORE	630	367	653	0	0	0	0	0	0	0	0	0	0	0	396	448	626	639	603	376	591
AFTER	435	384	447	0	0	0	0	0	0	0	0	0	0	0	330	496	394	465	383	352	369
DIFFERENCE	205	186	223	0	0	0	0	0	0	0	0	0	0	0	223	235	246	239	218	229	222

	MAY-1922																			
	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
BEFORE	599	661	678	X	X	617	672	628	649	586	581	579	571	576	572	537	600	607	591	607	612
AFTER	366	407	422	X	X	410	429	370	382	398	361	357	349	357	346	341	378	395	390	394	396
DIFFERENCE	233	254	256	X	X	207	243	258	267	188	220	222	222	219	226	196	222	212	201	213	216

FIG. 10. ECONOMIZER RECORD

ing the regular cleaning period. That is, the entire economizer is turbined, internally, every 16 weeks. The external surface is, of course, washed and scraped every regular cleaning period.

Operating Records

THERE ARE some 45 recording meters installed throughout the boiler house. These instruments are placed so as to afford all necessary information and data to operate the plant under what may be called continual test conditions, and to permit the striking of daily or weekly heat balances. The 24-hr. charts are changed promptly at 12 o'clock midnight and the next morning are placed in the hands of the plant accountant. He planimeters the charts, obtains daily or hourly averages as the case may be, and places the figures in the hands of the operating men.

At the end of the month, the average figures for that month are obtained and again at the end of 6 mo. and a year, respectively.

Realizing that records are only of value when applied and put into practice, they are plotted graphically and placed before the operators in that form. Typical specimens of these charts are shown.

A weekly heat balance is struck from daily averages and a chart plotted for the instructions of the operating force. Samples of these records are shown in Fig. 8. A summary of records kept for 1922 and the form used, is shown in Fig. 10.

A chemical laboratory is maintained as a part of the power department in which daily analyses are made of feed water. These analyses form the basis of recommendation for treating the water with lime and soda ash or caustic soda previous to its delivery to the feed water storage tank. It may here be stated that the water for feed purposes is taken from the Schuylkill River, which at this point is virtually a city sewer and in addition to this, its entire bed is composed of lime-

HEAT BALANCE NO. 18 Boiler House	
	Week ending 6-2-22
A - Overall Plant Efficiency	66.9 %
C - Loss Due to Moist. & H. in Coal	5.0 %
D - " " " Heat in Flue Gas	11.60%
E - Ash Pit Loss	14.50%
F - Loss Due to Exh. Going to Atmos.	1.50%
G - Rad. & Unacc. For	0.50%
Total	100.00%
B - Boiler & Econ. Efficiency	70.5 %
H - # Water Evap. (fhe 212) /# Coal as Fired	7.68%
K - " " " " " /# Comb.	10.8 %
J - BTU Burned /# Water Evap.	1178
L - % Rating	155
DATA	
1 - Steam Pressure	161 #/sq. in.
2 - Temp. Water to Heater (Est.)	140° F.
3 - " " from "	205° F.
4 - CO2	10.2
5 - Steam Delivered to Lines	7395 6997
6 - Steam Generated - Boiler Meters	7809 BHP
7 - Heat Value of Coal	10544 BTU/#
8 - Comb. in Ash	32.24 %
9 - Ash in Coal	23.30 %
10 - Stack Gas Temp.	398° F.
11 - Weight of Coal as Fired	32295 #/Hr.
12 - Moisture in Coal	5.7
Auxiliary Meter	812

FIG. 11. WEEKLY HEAT BALANCE REPORT

stone. These conditions, while unavoidable, make it an extremely difficult proposition to treat the water. For a detailed account of the methods employed in analyzing and treating this water, and for graphic representation of its constituents, the reader is referred to the article entitled "Boiler Waters I and II," by C. E. Joos and A. W. Binns, which appeared in the May 1 and May 15, 1922, numbers, respectively, of Power Plant Engineering.

Various graphical or mechanical methods are employed to indicate progress in operation from week to week. In the office of the chief operating engineer, for example, there are three chart boards showing operating records, combustion and steam quality, respectively. The type of board used is shown in Fig. 12. It consists of a wooden board mounted on the wall of the room with rulings upon it as indicated. Colored glass headed pins are used to plot the values, and, to make the curves continuous, cords are strung between the pins. One end of each cord is fixed to the end of the board while to the other end is attached a weight for the purpose of keeping it taut.

These charts are great aids in getting the operators to visualize the relation that exists between various

factors that make up operation as a whole. It is the aim of those in charge of the plant to interest the operators in their work, for they fully realize that it is only when a man is really interested in his work that he is most efficient. It gives him an opportunity to think,

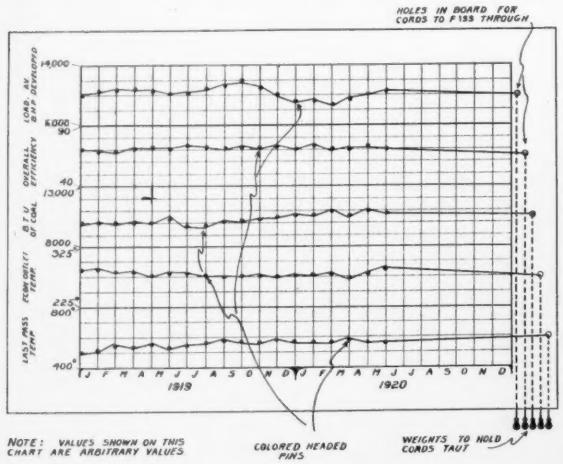


FIG. 12. DIAGRAM, SHOWING TYPE OF CHART USED IN CHIEF ENGINEER'S OFFICE FOR SHOWING PROGRESS IN OPERATION

and to exercise his creative ability. While this matter of "human engineering" has not been developed fully at this time, the management is planning to do much more along these lines. It is their intention to install charts in the boiler room on which operation will be plotted graphically so that the firemen may be able at all times to note the results of their efforts. The small amount of work that has already been done along this line has met with marked success.

ECON ON BOILER	GAS		WATER		BOILER OUTPUT LB. PER HR	PER CENT POSSIBLE GAS DROP	DEG. F. GAS DROP PER DEG. WATER RISE	B.T.U. TRANSFER PER SQ. FT. PER DEG. GAS DROP PER HR.
	IN	OUT	IN	OUT				

FIG. 13. ECONOMIZER DATA FORM

OBTAINABLE STANDARDS

IN REFERRING to obtainable standards, it will be well to state that by this term we mean the standards which may be obtained from day to day by ordinary operators under the usual trying conditions of varying coal, varying load, interruptions due to failure of apparatus, and other conditions which every operator is familiar with. These standards are the actual results over long periods of time and not merely test records of a few hours duration. The heat balance diagrams, Fig. 8, are a result of these standard conditions for the first three months of 1922.

Taking feed water from the river at an average yearly temperature of 70 deg. F., it flows over condensers in the process work of refining oil and is delivered to the boiler house at an average yearly temperature of about 110 deg. F. Flowing through the feed water heater, it is discharged at 210 deg. and is raised to 300 deg. in the economizers, at which temperature it enters the boilers.

The gases leave the boiler at 600 deg. F. and drop to 400 deg. in the economizers. The economizer gas temperatures (before and after) are measured by thermo-couples, the leads of which are brought to a central switchboard in the office of the chief operating engineer. At this point there is installed a bridge graduated in degrees F. by means of which the temperature at any one of the economizers can be read directly. These readings are taken hourly, and this average for 24 hr. is recorded in the daily economizer report shown

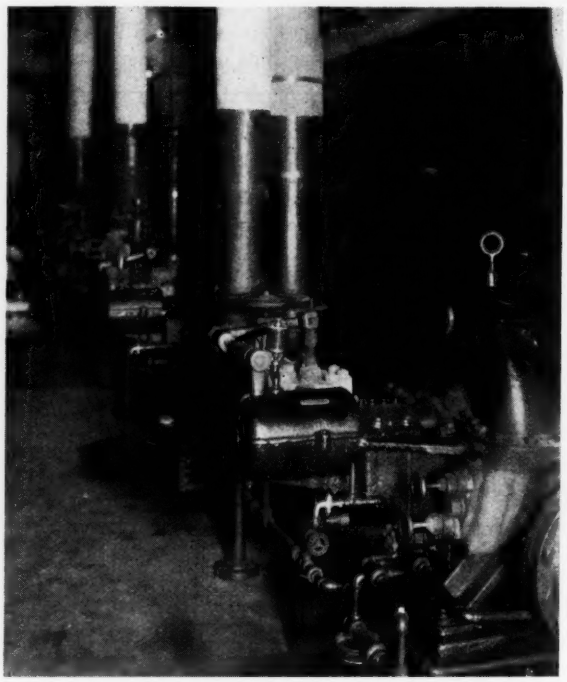


FIG. 14. VIEW IN PUMP ROOM

in Fig. 13. This report, it will be noted, contains all necessary data and is used in striking the weekly heat balance.

Ash pit losses of less than 10 per cent can be consistently maintained, while the overall efficiency of the plant is about 70 per cent.

As reference to the heat balance diagram will show, ten per cent of the total steam generated is used by the house auxiliaries. This is about 7 per cent of the heat value of the coal. The actual furnace and economizer efficiency averages about 77 per cent.

In other words, by maintaining rigid routine and constant vigilance, it is possible in practice to maintain a feed water temperature of 300 deg. F., an exit gas temperature of 400 deg., a boiler efficiency of 77 per cent, a plant efficiency of 70 per cent, an ash pit loss of less than 10 per cent and stack losses of approximately 12 per cent.

In concluding this article, it may be well to repeat that the foregoing figures represent the obtainable standards in every day practice, and are borne out in the actual performance of the plant.

The plant was built and designed entirely by the engineers of the Atlantic Refining Co.

Turbine Generating Unit Performance

DATA COLLECTED BY THE PRIME MOVERS COMMITTEE OF N. E. L. A. ON PERFORMANCE OF 78 TURBINES, SHOWS NEED FOR FURTHER IMPROVEMENTS IN TURBINE CONSTRUCTION

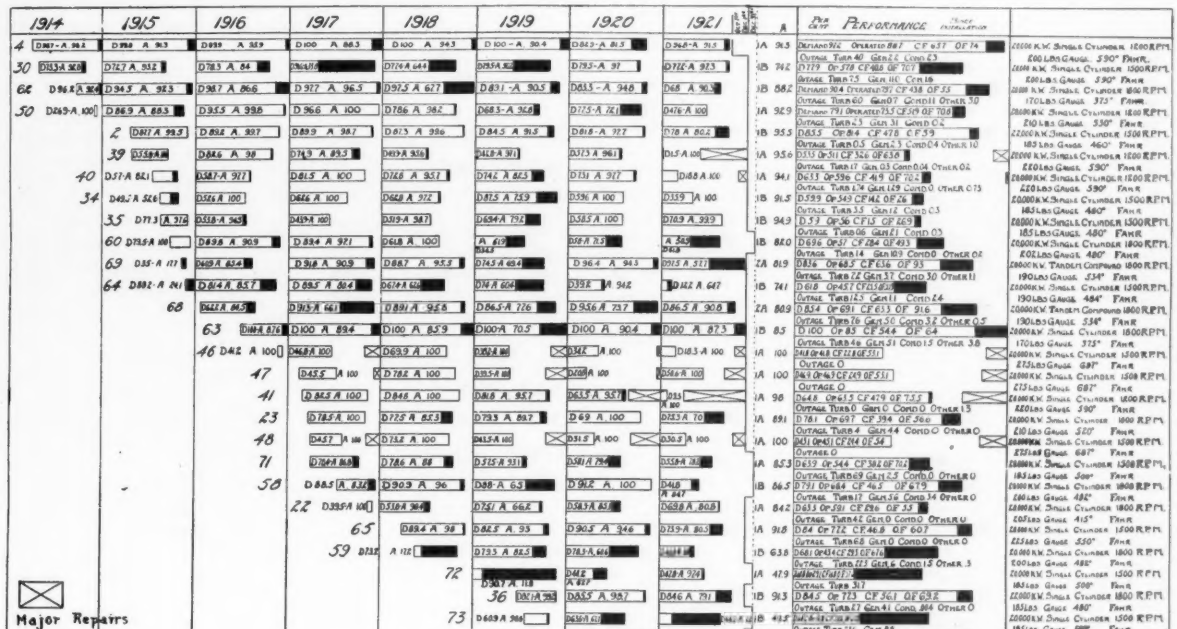
THE MOST important factor governing the design and construction of modern turbo-generators is reliability of service. While thermo-dynamic efficiency and overall dimensions are also of extreme importance, the ultimate standard by which the success of any turbine is measured is its degree of reliability of operation. For, no matter how high its efficiency may be, the machine is unsuitable if it cannot be relied upon to give continuous service.

The greater the reliability of the turbine available, the larger may be its capacity. This is obvious when it is considered that a machine of large capacity handles a greater portion of the total load, and its failure would cause a greater disturbance than the failure of a machine of smaller capacity. As pointed out by K. Baumann in a paper before the Institution of Electrical Engineers, even if the reliability of the different sizes available is the same, the power station itself will be less reliable with a small number of large units than with a larger number of smaller units. It is evident, therefore, that in order to maintain the reliability of the power station at a given standard, the larger machines should be more reliable, individually, than the smaller machines.

INCREASED CAPACITY DEMANDS INCREASED RELIABILITY

THE GENERAL trend in the development of large steam turbines in recent years towards the maximum possible output, should therefore have been accompanied by increased reliability of such machines over the smaller types. This, however, judging from the data collected by the Prime Movers Committee of the N. E. L. A. seems not to have been the case, as even a cursory examination of the accompanying charts will show. There seems to have been just as many failures, if not more, comparatively speaking, of large machines in the 31,000 to 45,000 kw. class as in the 20,000 to 24,000 kw. class.

TABLE I. PERFORMANCE RECORD OF TURBO GENERATING UNITS, 20,000 TO 24,000 KW. CAPACITY



Nobody is to blame for this condition in the progress of turbine development, however, and it must be accepted as a natural consequence of the rapid development of the industry. The demand for machines of large capacity has been so great during recent years that progress in the investigation and refinement of the quality of the materials and workmanship has been strained to its utmost.

The manufacturers are realizing more and more the importance of reliability of service and are endeavoring to strike a satisfactory combination of reliability and

efficiency. At the same time, the tendency towards refinement in the quality of materials and workmanship continues to receive attention and it is being more generally recognized that high efficiencies are obtainable only through these improvements.

A better understanding and closer co-operation between manufacturer and operator have contributed to miscellaneous improvements of the turbines as a class, and frank and open discussion of each one's troubles have given both a better appraisal of the situation and have led one to appreciate the other's view point.

An effort has been made to evolve a method whereby the performance of turbine generating units can be compared, irrespective of the character of enterprise they serve, and this method has been applied to a detailed study of the performance of a large number of turbine generating units typical of the state of the art today.

fering with the ideal performance required since these units were first placed in continuous service.

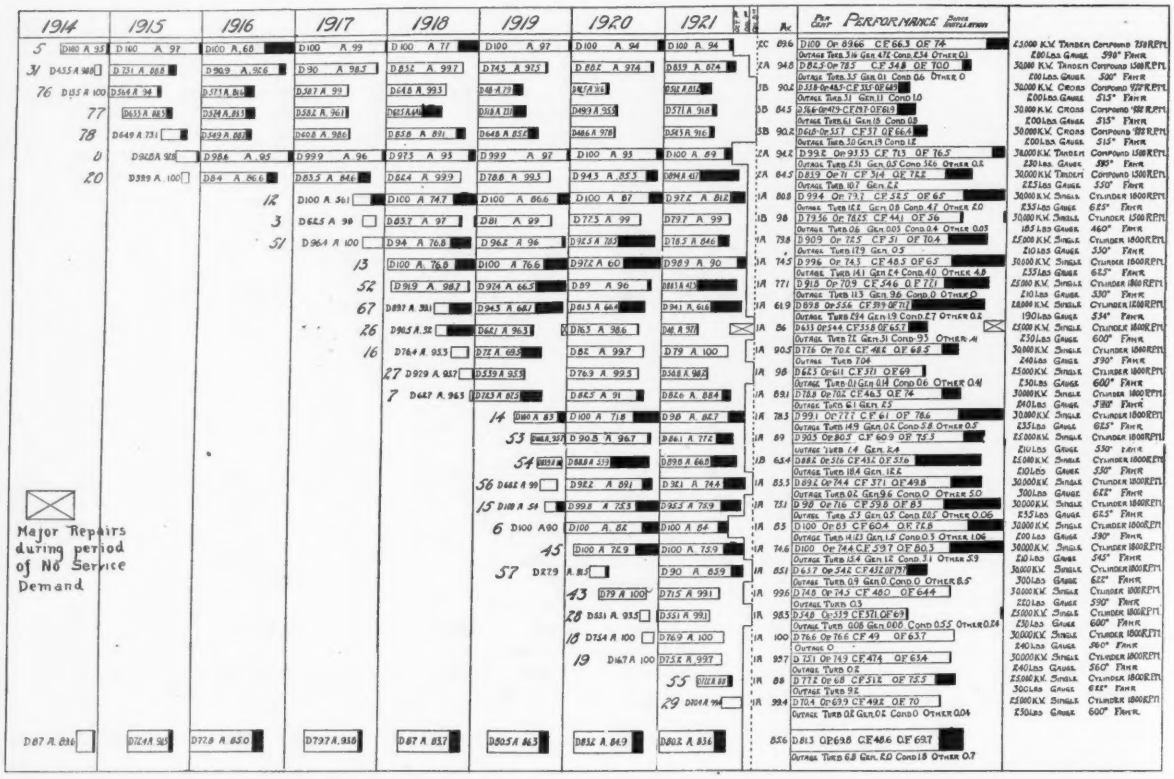
These data are herewith presented graphically, true proportions being used and an explanation given as to the basis of comparison used.

Explanation of Factors

Obviously, the performance of the complete turbine generating unit, that is, the turbine, generator, condensing equipment, boilers, etc., is controlled to some extent by the percentage of installed time there is demand for operation of the unit. This has been specified as the service demand factor, D, which is the ratio of the operating demand hours to the hours elapsed in the period that the initial installation was considered as complete.

Operating demand hours are those involving opera-

TABLE II. PERFORMANCE RECORD OF TURBO GENERATING UNITS, 25,000 TO 30,000 KW. CAPACITY



To secure these data required the complete examination of comprehensive operating logs maintained for these turbines, from the time their initial installation was completed; that is, when they were first placed in regular commercial service. This necessarily confined the investigation to the larger turbines confined in large stations.

Through the co-operation of 27 large power plants with the Prime Movers Committee of the N. E. L. A. complete data on 78 turbines was placed at the disposal of the committee, from which the accompanying charts were constructed. These turbines ranged in rated capacity from 20,000 kw. to 45,000 kw.; the records reported being continuous as to output, service requirements, operating performance and respective difficulties interfering with the ideal performance required since these units were first placed in continuous service.

These data are herewith presented graphically, true proportions being used and an explanation given as to the basis of comparison used.

Explanation of Factors

Obviously, the performance of the complete turbine generating unit, that is, the turbine, generator, condensing equipment, boilers, etc., is controlled to some extent by the percentage of installed time there is demand for operation of the unit. This has been specified as the service demand factor, D, which is the ratio of the operating demand hours to the hours elapsed in the period that the initial installation was considered as complete.

Operating demand hours are those involving operation of the unit for meeting every load requirement on it, also maintaining the maximum plant efficiency that was possible through the operation of the particular unit considered.

The Unit Operating Factor, O.P., is the ratio of the total hours operated to the elapsed hours since the initial installation was completed referred to the period of time considered, and is a value lower than the Service Demand Factor by an amount which represents the time the entire unit was idle for some cause or other, although to secure the best returns from the plant required its operation. This difference is called Outage Factor, or the ratio of the total hours the unit was idle, when there was operating demand, to the elapsed hours since the initial installation was completed. This outage

time was divided between the turbine, the generator, the condensing equipment, and other causes aside from these as indicated from detailed study of operating history contained in the power plant logs.

Service Demand Availability Factor, A, is the ratio of the Unit Operating Factor to the Service Demand Factor. It is a measure of how nearly the complete installation came to meeting every demand the particular power station enterprise imposed upon it.

To define the activity of the total unit installation, a Unit Capacity Factor, C.F., is used which is the ratio of the total generated kilowatt hours since the initial installation was completed, to the unit kilowatt capacity rating multiplied by the elapsed hours.

The indication of how much the capacity was utilized during the time the unit operated is stated as Unit Output Factor and is the ratio of the total generated kilowatt capacity rating multiplied by the hours of actual operation.

The 78 horizontal turbine generating unit installations were segregated into three divisions:

1. 20,000 to 24,000 kw. inclusive.
2. 25,000 to 30,000 kw. inclusive.
3. 31,000 to 45,000 kw. inclusive.

Tables I, II and III indicate the yearly performance of the turbine generating units of each division stated above, their total average performance for the period since installation, also the yearly average performance of all units operating at that time.

The service requirements appear to fall into three classes, governed by the power station enterprise and the consumers served:

Class I. Turbine generating units which are required up to 65 per cent of the time. These are in power stations operating as a reserve plant on water-power systems; also in plants whose load is such that the operation of the turbine generating unit considered is only to serve a peak demand of relative short duration or is used as a reserve unit.

Class II. Turbine generating units which are required to operate from 65 to 85 per cent of the time. In this division are included those plants serving the larger cities with a load curve of the typical metropolitan peak type.

Class III. Turbine generating units which are required to operate 85 to 100 per cent of the time, these installations serving continuous demand through the work-day week, handling the steady basic system load.

The weighted average performance of units in the three classes is shown on Table IV.

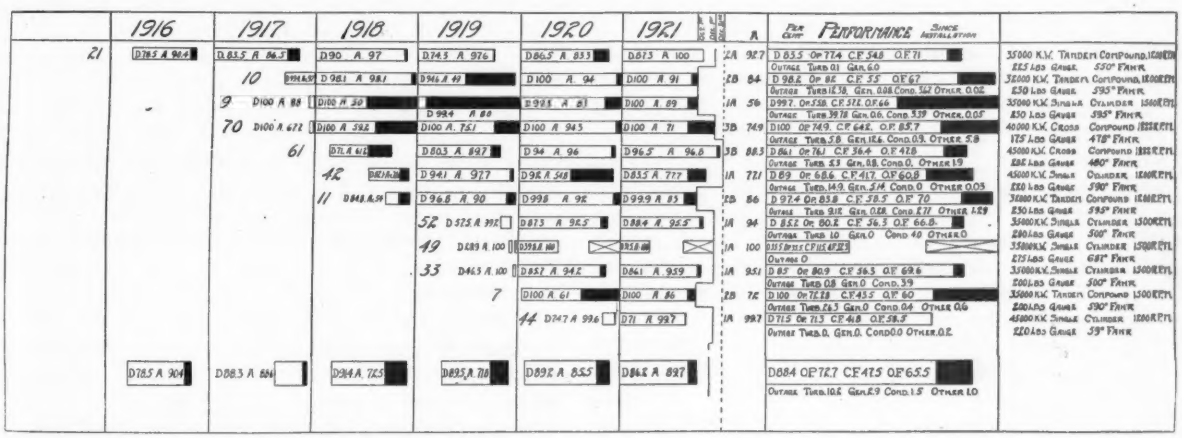
These performance records cover the entire operating life of about 50 per cent of the largest turbo-generators in the country throughout their normal and abnormal periods of operation and service and form a fair basis from which to calculate the reserve equipment safely to maintain service.

TABLE IV. AVERAGE PERFORMANCE OF UNITS

Service	*Class I*	*Class II*	*Class III*
Turbine Units	24	25	29
Service Demand Factor Range	34–64.8%	68.1–84.5%	85.–100%
Weighted Averages			
Years Installed	4.1	3.45	3.79
Service Demand Factor	57.1%	79.00%	94.10%
Unit Operating Factor	50.9%	68.50%	77.80%
Service Demand Availability Factor	89.2%	86.70%	82.70%
Turbine Outage Factor	4.4%	6.10%	9.70%
Generator Outage Factor	1.1%	3.60%	2.90%
Condenser Outage Factor	0.4%	0.70%	2.30%
Other Causes Outage Factor	0.3%	0.10%	1.30%

An examination of the average performance of Tables I, II and III indicates the results of improvements made to secure the greatest degree of reliability of the turbine due to the combined efforts made during the past two years by operators and manufacturers.

TABLE III. PERFORMANCE RECORD OF TURBO GENERATING UNITS, 31,000 TO 45,000 KW. CAPACITY


1916
1917
1918
1919
1920
1921
PERFORMANCE SINCE INSTALLATION
35000 K.W. TANDEM COMPOUND 1500 R.P.M.
35000 K.W. TANDEM COMPOUND 1800 R.P.M.
35000 K.W. SINGLE CYLINDER 1500 R.P.M.
40000 K.W. CROSS COMPOUND 1800 R.P.M.
45000 K.W. CROSS COMPOUND 1800 R.P.M.
45000 K.W. SINGLE CYLINDER 1800 R.P.M.
35000 K.W. TANDEM COMPOUND 1800 R.P.M.
35000 K.W. SINGLE CYLINDER 1500 R.P.M.
35000 K.W. SINGLE CYLINDER 1500 R.P.M.
35000 K.W. TANDEM COMPOUND 1500 R.P.M.
45000 K.W. SINGLE CYLINDER 1200 R.P.M.

For Class III service, it is evident that a number of important details affecting operation must now receive particular attention to insure greater availability of the unit, such as clean air for generator ventilation, facilities for cleaning condensers while operating, duplication of the more essential auxiliaries, etc.

The trend of power station operating conditions is continually in the direction of increasing the Service Demand Factor on the apparatus installed and all component parts of the complete unit installation must in so far as possible be arranged so that maintenance and repair work may be conducted without rendering the turbine generating unit idle.

Dangerous Half Truths in Power Records

WEIGHTS SHOULD BE CHECKED UP BY HEAT BALANCE. BY DOUGLAS HENDERSON

IN THE drive for information on power plant operating results, many executives are victims of inaccurate and insufficient data which usually is in favor of the power plant to the extent of producing satisfaction whereas quite the reverse ought to be true. There are many industrial power plants that are equipped with meters for measuring the water fed to the boilers and also to weigh the coal burned. Every 12 or 24 hr. a record is made of these two quantities and forwarded to the office. At the office the water weight is divided by the coal weight producing a figure representative of the "evaporation per pound of coal" obtained over the period. This evaporation is listed day after day, and in many cases it is charted so that the change from day to day can be visualized. The plants going through the operations set forth above have no doubt found this curve jumping around and the only reason assigned for the cause is manipulation of fires. The truth of the matter may be more with coal quality than with operation. To get at the real answer requires a knowledge of the coal actually fired, for a slump in heat value will cause a drop in evaporation.

This is just an idea how incomplete data will result in false conclusions. The operation of weighing coal and measuring water is a step in the right direction. There is no question about that, but it is not far enough. A few actual examples of the pitfalls that underlie this scheme will serve to good purpose.

Quite recently a large industrial plant undertook a boiler test with a particular kind of semi-bituminous coal in order to determine just what results could be obtained. The conclusions in the matter would necessarily have an effect upon their coal buying. The test was conducted upon a vertical water tube boiler rated at 585 hp., which was fired with an overfeed stoker. An 8-hr. run was made during which coal and water weights were taken. In addition to this a CO_2 recorder furnished a continuous record of gas analysis throughout the test and recording draft gage, feed water thermometer, and steam pressure gage supplied the rest of the data. The averages of the 8 hr. can rapidly be seen from the following tabulation:

Total weight of water fed to boiler	240,000 lb.
Total weight of coal burned	24,160 lb.
Actual evaporation per lb. coal	9.95 lb.
Average CO_2 percentage	10.6 per cent
Feed water temperature	144 deg. F.
Steam pressure by gage	120 lb.
Flue gas temperature	690 deg. F.

A sample of the coal burned was analyzed and the following report obtained:

Moisture	2.70 per cent
Ash as fired	10.91 per cent
Volatile dry	16.86 per cent
Fixed carbon	69.98 per cent
Sulphur	2.77 per cent
B.t.u. per lb. as fired	13,383

A representative sample of the refuse during the entire 8 hr. was collected and tested for the percentage of unburned carbon content. It was 37.75 per cent.

The evaporation obtained by dividing the water fed to the boilers by the coal burned gave 9.95 lb., an entirely satisfactory figure. Computing the efficiency of boiler, furnace and grate on this basis gives 77.6 per cent, a figure that all power plant men aspire for but seldom reach. On the face of these results, satisfaction is bound to exist; let us complete the story by establishing a heat balance.

Tabulating the various losses that occurred during the process of combustion in this case, we get the startling result:

Heat balance based on coal as fired—

	B.t.u.	Percent
a. Heat absorbed by the boiler	10,710	77.60
b. Loss up the stack	2,720	20.30
c. Loss due to unburned carbon in refuse	960	7.18
d. Loss due to moisture in coal	36	0.27
e. Loss due to hydrogen in coal	500	3.74
	14,926	120.09

The total of the items listed amounts to 1543 B.t.u. more than the heat in the coal at the start. Expressed in percentages the total exceeds 100 per cent by 20.09 per cent. The situation thus developed makes it impossible to determine the radiation and unaccounted for loss by difference. To take the evaporation figures of 9.95 lb. water per lb. coal is incorrect.

If the radiation factor in this test amounted to 4 per cent which is a reasonable figure, the efficiency would be 64.5 per cent instead of 77.6 per cent, and the evaporation per lb. of coal would have amounted to 8.10 lb. These figures are certainly more in keeping with actual experience than are the results of the test.

Take another case. Here was a test made on a 335-hp. return tubular boiler fired with a chain grate stoker under forced draft. Water and coal weights were recorded as well as flue gas temperatures, steam pressure feed water temperature and complete flue gas analysis. A 10-hr. test produced the following averages:

Total weight water fed to boiler	126,000 lb.
Total weight of coal burned	17,485 lb.
Actual evaporation per lb. coal	7.21 lb.
Average CO_2 percentage	8.06 per cent
Feed water temperature	180 deg. F.
Steam pressure by gage	102 lb.
Flue gas temperatures	630 deg. F.

A coal sample taken over the period of the test and quartered down, when analyzed proved to have the following composition:

Moisture	2.90 per cent
Ash	21.83 per cent
Volatile	5.90 per cent
Fixed carbon	69.38 per cent
Sulphur	0.53 per cent
B.t.u. per lb	11,252

The sample of this refuse contained 41.89 per cent unburned carbon.

In this case, the fuel used was anthracite yard screenings and the attractive price at which they could be purchased was an important reason for their being

used. The evaporation figures of 8.06 lb. gave an efficiency of boiler, furnace and grate of 66.50 per cent, which again pointed toward economy in steam production.

The heat balance told a very different story. Working out the losses as before enabled the tabulation to be made:

Heat balance based on coal as fired—

	B.t.u.	Per cent
a. Heat absorbed by the boiler	7,480	66.50
b. Loss up the stack	2,865	25.46
c. Loss due to unburned carbon in the refuse	2,280	20.25
d. Loss due to moisture in coal	38	0.34
e. Loss due to hydrogen in coal	257	2.28
f. Loss due to incomplete combustion	356	3.17
Total	13,276	118.00

The heat accounted for amounts to 2024 B.t.u. more than the heat in one pound coal as fired, leaving the radiation and unaccounted for difference out entirely. This exposition demonstrates that the original results are worthless and that the true efficiency is probably nearer 45 per cent with the evaporation figure about 4.81 lb.

The error in this latter plant was traced to the failure of the coal passer to record some of the coal weights. This is not an infrequent occurrence and one that results in better showing for the plant operation than is the case. The loss of water through leaking blowoff valves will also color the evaporation in favor of the boilers producing results that are absurd when placed under the scrutiny of the heat balance.

Errors in coal weights are more prevalent than is generally conceded. Even plants equipped with weigh larries are not immune from mistakes in this connection. Frequently a 1000-lb. weighing machine will be overloaded, due to the failure of the operator to shut off the main hopper in time, and the result is that a much lower coal weight is recorded than represents the coal actually burned. This again works in favor of the operating results.

An amusing case of weight dodging occurred at a small industrial plant that was anxious to make an effort at coal economy by weighing all that was wheeled into the boiler room to be fired. There were two doors to enter the fire room and near each one had been located a scale with necessary runway up to and away from the platform. It appeared necessary for the coal passer to run on to the scales in order to get the coal in front of the boilers. But such was not the case. Every so often the passer would wheel a barrow load of coal on the threshold of the door and stop for a minute apparently to rest. Instead it was to locate the whereabouts of the chief, and when assured he was not in sight the coal passer rapidly skirted the scales and deposited the contents of the barrow on the coal pile ready for the firemen. The coal thus wheeled in never was recorded and the daily total was not indicative of the kind of results obtained.

It might be suggested that this sort of thing cannot go on indefinitely before it is detected, for in the end the coal inventory is bound to show more coal on the books than is on hand in the yard. That, of course, is true; but seldom indeed does the amount of coal on hand in the yard ever check that shown on the books. Unless the scheme is checked up at monthly intervals by means of a heat balance, there is no way of getting at the discrepancy.

After all, the important point is to get the best results possible from the coal burned and it has already been demonstrated that merely weighing coal and water is not sufficient. Records of flue gas temperatures, CO_2 percentages developed, feed water temperatures, steam pressure, coal and ash analyses all are of equal importance to the one interested in getting the facts in the case upon which opinion and judgments can be based.

Coal for Chicago's Office Buildings

PRESENT SITUATION AS EXPRESSED BY ENGINEERS OF TYPICAL DOWNTOWN BUILDINGS

PERHAPS the engineers in building power plants of Chicago take more precautions against shutdown than the average fuel user throughout the country. Many of them had unpleasant experiences during the fuel famine 4 yr. ago. At any rate, with scareheads in daily newspapers predicting a coal famine within a very short time, it would be natural to expect at least some anxiety among the engineers in regard to their fuel supply; but a canvass of a number of typical downtown building power plants reveals an attitude of "why worry." That the strike will all be over in another month seems to be the general opinion.

Like any cautious engineer, however, nearly all took advantage of the warning given them a few months ago and stored enough coal to run them for from one to three months and do not propose to use the stored coal until forced to do so by shortage in the open market or until the mines are producing their normal output.

The New York Life Building, for example, is typical of many in downtown Chicago. The chief engineer of the power plant in this building is Warren Moon, who states that the coal being burned now is Pocahontas pea and is very well adapted to his furnaces. This coal is purchased in the open market as needed, no contract having been entered into with dealers. Anticipating the strike, however, three months supply of No. 4 Illinois nut coal was stored in one of the coal company's yards and this is still held in reserve.

At the Rand McNally Bldg., it is customary to keep two months' supply of coal on hand. This is secured in the open market from coal dealers and as yet no difficulty has been experienced in getting deliveries promptly as requested. Mr. Hartman, the superintendent of the building, thinks the mines will all be working in 30 days.

Three months ago John C. Heavey, chief engineer of the North American Building, stored a sufficient amount of No. 4 Illinois nut coal at a coal company's yard to supply the needs of the building for two and a half months. Only a small amount of this stored coal has been used, the plant depending on coal purchased in the open market for its regular fuel supply. At the present time, a good grade of Kentucky coal is being secured, the deliveries being prompt.

At the Fisher Building, a different situation exists. E. B. Clarke, the chief engineer, purchases his coal on 60-day contracts, his reserve supply being sufficient to last only a few days. The coal now coming to the plant

is a good grade of Kentucky No. 4 washed nut with a heat value around 13,000 B.t.u. Deliveries have been as regular since the strike was called as before and there has been no warning from the coal dealers that deliveries cannot be obtained. Due to the fact that among the tenants of the building are about 50 coal dealers, the building is reasonably sure to secure coal if it is to be had. Mr. Clarke places the date at which a coal famine is likely to start, under present production at about 60 days hence.

"We have no trouble in getting all the coal we want now," said Thomas Naughton, of the Kimball Building; "however, if some settlement of the strike is not apparent in a couple of weeks, we shall increase our storage supply which is sufficient at present to run us for 20 days." Local dealers are supplying the plant with Kentucky screenings at the present time for immediate consumption.

At the Great Northern Hotel, J. H. Morrow states, one month's supply is kept in storage, the coal for immediate use being delivered by the dealers as needed. Assurance has been given that the dealers will keep the building supplied with its needs. The plant is now burning Indiana and Illinois No. 1 nut.

The Ellsworth Building usually secures its coal from mines of the owner of the building; these, however, were shut down at the beginning of the strike since which time coal is purchased in carload lots direct from West Virginia mines. C. G. Brown, the chief engineer, reports sufficient coal on hand to run the plant two months.

These specific cases are sufficient to illustrate the general attitude of engineers in this class of power plants which, as a rule, has less facilities for storing coal than any other class. Everybody recognizes that the situation, if continued, is bound to result in a serious fuel shortage and all are watching closely every move of the miners, operators and the Government so that all reasonable precautions can be taken in time to prevent a shutdown.

Oil Engine Hints---II

FUEL TIMING; PREHEATING FUEL; AIR IN FUEL; FUEL SUPPLY SYSTEM; INJECTION AIR. BY BERT BARE

THE QUESTION of fuel control resolves itself into timing and the grade of fuel used. The timing to some extent will be dependent on the grade of fuel, the lower the grade, the earlier the time of injection. This is a feature that needs more watching in the lower compression engines than where higher pressures are used; in fact, the timing of the "full Diesel" will vary but little for the different fuels. The method of fuel treatment before injection will then play a more important part. In the lower compression engines, the difference in timing as between a light or heavy fuel will amount to as much as 30 deg.

It has, therefore, been found desirable by manufacturers of engines of this type to equip them with some method of adjustment for timing while the engine is running. For one particular kind of fuel one setting of the timing is all that is necessary, but where the fuel obtainable is subject to variation, adjustment of the timing is necessary with each new shipment. This point will readily be appreciated by marine men. In the Hvid or Brons type where the fuel enters the cylinder on the suction stroke and falls into a perforated cup, the size of the holes will vary with the grade of fuel used, the lighter fuel requiring the smaller holes. In all the cases just cited, if the timing is set for the heavier fuels, the use of lighter fuels without adjustment of either the timing of injection or of the cup, will cause preignition. The remedy lies in making the proper adjustment.

PREHEATING HEAVY OIL

IN ALL the types of engines the heavier fuels require treatment before reaching the fuel nozzles. Where the heavier fuels, say from 18 deg. Baume down, are used, it will be found that heating of the fuel will be necessary to obtain the required fluidity. Where the fuel is delivered to the injection pump suction under atmospheric pressure, there is always liable to be trouble in getting the pump to work well. The heavier fuel requires greater suction and this causes, in turn, a tendency to vaporization where the fuel has been heated to between 125 and 150 deg.

Also the higher vacuum necessary, will be a greater source of danger of drawing air into the line. Where the fuel discharge is subject to high pressure, a minute amount of air in the line will cause failure to operate.

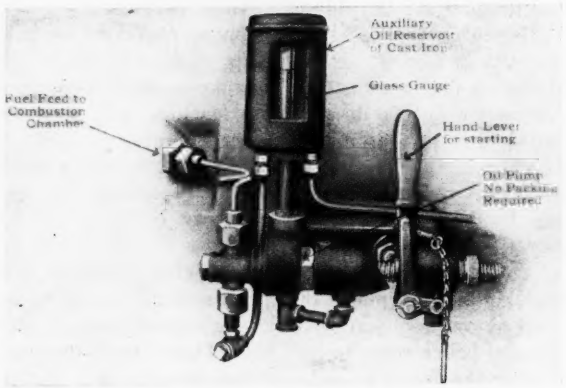


FIG. 1. OIL INJECTION PUMP AND AUXILIARY RESERVOIR

This refers to the mechanical injection type and in this case the pressures will run from about 1000 to 4000 lb. per sq. in. So it can be seen how careful one must be to keep the line clear of air.

Where these high pressures are used, it is necessary to have the connecting lines, which are subjected to these pressures, of small diameter and of seamless steel tubing. Copper tubing will not do because at the high pressures a small amount of sulphur in the fuel will eat into the copper. Steel will also better resist expansion stresses and lessen the evils due to a maintained pressure that expansion of the line might cause.

AIR IN FUEL LINE

This trouble of getting air into the line is important because it is so hard to trace the trouble when the pump fails to work from this cause. Knowing that air in the

fuel line is hard to trace, it is often surmised that this is the trouble when the real trouble lies in the restriction of flow in the suction line. Suction lines should have ample cross sections. It is, therefore, best always when looking for trouble with air to see that there is an adequate and free flow of fuel to the injection pump suction. A partial vacuum in the suction line will act the same as air in the delivery line.

These three troubles:—restriction of the fuel pump passages, which must be made small to keep the pipe stresses low; the tendency to vaporization; and the danger of air leaking into that part of the line under suction,—all of which are correlated and hard to separate when looking for trouble in the injection pump,—can be almost entirely eliminated by supplying the fuel to the injection pump suction, under pressure, which need not be over 10 lb. per sq. in. Practically all engines are now supplied with a small fuel supply pump. This can be so connected that it bypasses on itself through pressure check valve set at about 10 lb. The fuel will flow from the day tank to the fuel supply pump and the pump will then supply fuel under pressure to a small tank fitted with a small air chamber. The fuel should flow into this tank just below the surface of the oil so as to prevent agitation with air in the air chamber. The fuel should then be connected from the bottom of this tank to the suction of the injection pump. The spring on the valve of the suction of the injection pump should be made stronger to compensate for the higher pressure now used.

Fuel Supply System

In all cases where the fuel is heated, it is better to use the jacket water rather than steam so as to prevent overheating the fuel. Where the pressure suction method is used for the injection pump, a small pipe or tube coil may be fitted into the line so that the discharged cooling water will form a bath for the coil and thus be amply efficient for heating. The pressure in the suction line will take care of the additional friction of the heater coil.

It is well to fit a gage glass to the air chamber so as to show the fuel level. The air chamber is to take care of the pulsations of both supply pump discharge, which is better run at slow speed, and the injection pump suction. It will also act as a trap for any air that may have found its way into the line through the supply pump. A pet-cock at the top of the air chamber will be found convenient to regulate the height of fuel in the air chamber.

The amount of fuel allowed above ground will depend on the insurance rules governing the condition. In some cases, this amount is not over one gallon. Where it is desired to carry a greater amount of fuel under pressure, this can easily be done by pumping to a day tank and having a large enough air chamber attached so that this arrangement can be used as an accumulator and fuel can be supplied, under pressure, to the injection pump for some time in case it is necessary to "cut out" temporarily the fuel supply pump.

Where the engine is fitted for adjustment of timing while the engine is running, this can be done without any further trouble. The adjustment should be made such that the firing takes place as early as possible without "knocking." In the "full Diesel" type where air-injected fuel is used, the cam operating the fuel valve has an adjustable nosepiece. This should be set so that for normal load and speed the indicator card shows a horizontal line from the end of the compression line. This nosepiece should be fitted with a back-stop so as not to rely on the bolting alone to keep the nosepiece in place.

Leaking Fuel Valve

Preignition is not always due to the early timing of the fuel. There may be what is known as "after-drip." This is the dropping of the fuel into the cylinder at a time when the heat is not enough to cause ignition and after the main charge has ceased to burn. The fuel, then left in the cylinder, falls on top of the piston and on the compression stroke is in a condition, due to the heat of compression, to ignite before the piston has reached top dead center. In the mechanical injection engines, this trouble is more pronounced and special precautions are necessary to reduce the pressure in the line after the main charge has been injected.

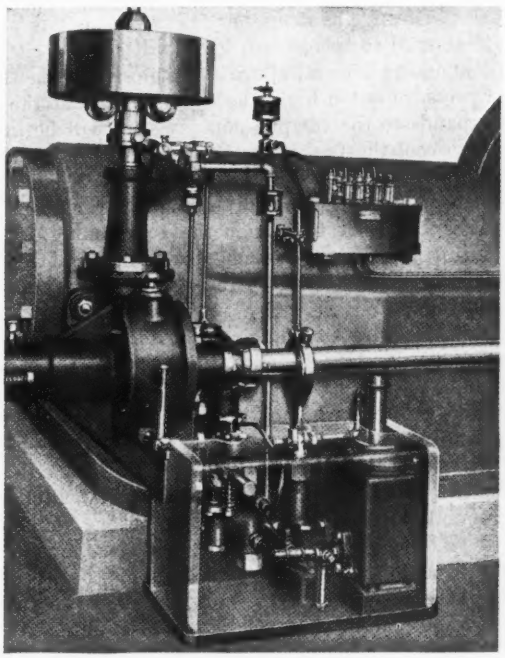


FIG. 2. GOVERNOR AND FUEL PUMP ON HORIZONTAL OIL ENGINE

This trouble is reduced to a minimum by having the discharge or fuel control valve of the injection pump of such a character that the pressure in the connecting line is relieved at the end of the injection stroke.

This is not a necessary feature with the air-injected fuel engine because the fuel is delivered to the injection nozzle or atomizer some time before the time for the injection of the fuel into the cylinder. In both cases, however, the spring controlling the valve at or near the point of injection must be kept up to its proper amount of stress. This spring, as well as the main valve springs, should be placed outside the head if possible so that any breakage can be quickly detected and also so that the springs will not be subjected to great heat. Where the spring is so placed as to become heated, it will be necessary to use the best heat-resisting spring material

available; otherwise the heat will weaken the spring and it will not act promptly in cutting off the fuel, nor will it be able to hold the valve securely in its proper place.

Relief of the pressure at the injection pump will help the spring at the nozzle but it will not be able to help control the fuel that would flow past the valve into the cylinder by gravity. Where "after-drip" is suspected, it may be due to the weakening of this spring or it may be due to the valve seat becoming burned, or to scale forming and thus preventing the valve from seating properly. Air in the line will tend to maintain pressure in the line and also be the cause of "after-drip." Where air injection is used, the "knocking" may be due to the use of too high a pressure in the injection air.

Injection Air

When starting up under no load conditions this pressure should not be more than 550 to 600 lb. per sq. in. As the load comes on, the pressure should be increased. Strange as it may at first seem, the air pressure, if allowed to become too high, will cause a change from "knocking" to a failure of explosion altogether. If the pressure is too high, the cooling effect of the air as it expands to the compression pressure will be great enough to cool the fuel below the temperature required for ignition and so cause failure to ignite. In addition to changing the air injection pressure for changes of load, it is also well to change the fuel timing. Both these adjustments can be taken care of by hand adjustment, if the engines are not equipped for their mechanical control.

In the medium and high-compression engines when "knocking" develops in one of the cylinders, it is a good thing to take a look at the nozzle valve at the first opportunity to see whether it is not in such condition as to cause "afterdrip."

In some cases where the air injected "full Diesel" engine has the fuel valve opening into the cylinder, a sudden and violent "knock" develops in one of the cylinders. The cause of the trouble may be immediately diagnosed as a burned fuel valve. In this case as in all cases where there is a very bad "knock," the fuel to that cylinder should be immediately "cut out." If the engine then runs all right, the defective cylinder may be looked after without stopping the engine. If, however, the engine still gives trouble, it should be shut down completely.

There are times when a low compression engine shows very fine fuel consumption figures,—that is, fine for this type of engine. The amount of lubricating oil consumption should then be looked after, because it may well be that the engine is using some of this lubricating oil as fuel. This is very likely to happen in the case of a two-cycle crankcase-compression engine. Where there is a tendency for the engine to use lubricating oil for fuel there may also be a tendency to preignition not traceable to other causes. This will be more pronounced in the higher compression type. This cause will be found in the fact that the lubricating oil is drawn into the cylinder by the scavenging air in the form of a vapor and when the compression becomes high enough, but before the maximum pressure has been reached, this oil will burn, causing the preignition.

Low Cost Power

Repairs, Attendance and Fuel at a Minimum. By L. H. Hale

We always like to talk about our oil engine plant, for it is such a source of joy to us that we just can't help it. Our plant consists of a 300-bbl. flour mill with elevator and feed mill, the latter across a driveway and driven by a line shaft. The rest of the mill is driven by a rope drive having six wraps of 1½-in. rope, on the American system. The engine sheave is 56 in. diameter and that on the mill roller line is 72 in.

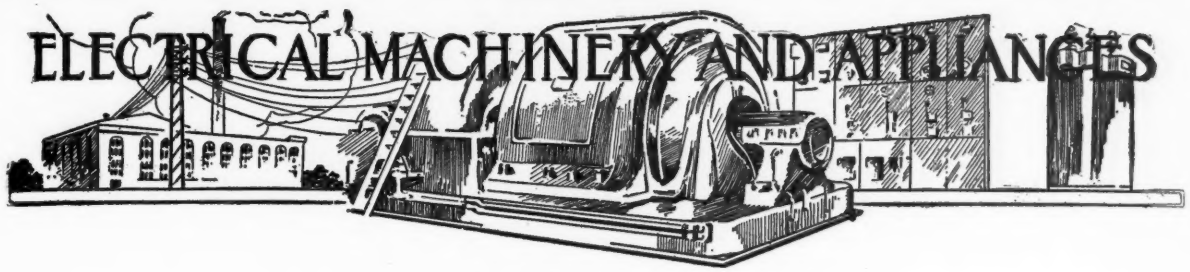
The engine is 125 hp. at 227 r.p.m., with twin cylinders 14 by 21 in., four cycle, and having a flywheel 10 ft. diameter weighing 16,000 lb. In the flour mill are four double stands of Wolf's ball bearing rolls, 9 by 30 in. and four double stands 9 by 24 in. with Wolf's square sifters four sections each, a Little Wonder reel, three middlings mills, three flour packers for standard packages, one small package packer and two feed packers. There are also a wheat washer, a milling separator, two wheat scourers, one double and one single, a rolling screen, a magnetic separator, a batch mixer and the other machinery to be found in a strictly modern flouring mill.

We are making 11 bbl. of flour an hour, driving the elevator and feed mill, heating and lighting the mill, office and elevator, all for less than 35 cents an hour for fuel and lubrication oil costs. We also pump all the water used by the wheat washer from driven wells. The plant has been in continuous operation since June, 1915, and upkeep on the engine has cost to the present time probably less than $50, consisting largely of piston rings which wear out at the rate of six rings per year.

We have used various degrees of fuel oil, but find that for the cold winters here in Ionia, Mich., the 30 to 34 deg. fuel oils give the best satisfaction, as they do not congeal at low temperatures, burn with little carbon and are relatively as cheap as the lower test oils. We have used as heavy as 26 deg. oil and as light as kerosene, all with good results. Cost of these oils varies with the general oil market: in 1915 we paid 4 to 3.15 cents; in 1916, 3.85 to 4 cents; in 1917, 4 to 4.5 cents; in 1918, 6 to 9.3 cents; in 1919, 7.5 to 7.75 cents; in 1920, 7.5 to 6.95 cents; in 1921, 6 to 5.5 cents, and so far in 1922, 5.65 cents.

The Allis Chalmers Co., makers of the engine, guarantee a fuel consumption per horsepower-hour of 0.50 lb., but in actual practice this is bettered by a considerable fraction, though we do not have the instruments to make a careful technical test. We find that the feed mill earns enough for custom grinding to pay the total cost of the engine power and leave a small profit, but we reverse the process and charge all power costs to the flour mill. The attendance cost is so low that we do not attempt to charge this up as costs per barrel of flour made, but the power cost is less than 5 cents per barrel made.

An idea of the cost for heating and light can be had from the size of the mill, which is four story, of paving brick slow burning construction with steel sash. There is also a warehouse 40 by 80 ft. with loading space for two cars. We are not power experts, but we like this kind of power.



Auto-Transformers---II

DETERMINING THEIR RATING AND FACTORS GOVERNING THEIR SELECTION. BY FRANK C. VOGAN

IN COMMERCIAL practice, the rating of an auto-transformer in volt-amperes is taken as being the difference between the high and low voltages multiplied by the rated current in that part of the winding F to C as shown in the figures, or across which this voltage exists. The capacity of an auto-transformer for a given work bears to the two-winding or straight transformer for the same purpose, the rating $\frac{E_1 - E_2}{E_1}$. This has already been mentioned as the copper ratio. For example, to reduce or step down the voltage of a feeder from 220 to 110 v. and supply a load of 20 kv.a. would require an auto-transformer having a ratio of $\frac{220 - 110}{220} \times 20$, which equals 10 kv.a. as against a straight transformer having a capacity of 20 kv.a. The weights, dimensions and costs of auto-transformers are nearly the same as for ordinary two-winding units of the same kv.a. rating. The smaller the ratio of transformation, the greater is the gain in cost and efficiency resulting from the use of an auto-transformer instead of a two-winding unit. To visualize how the auto-transformer rating is worked out and how this rating compares with the rating of the two-winding type, the reader is referred to Fig. 5—to which the data in the following example applies. In a given case, suppose it is required to reduce a potential of 200 v. to that of 160 v. and serve a load of 10 amp. Neglecting all losses and reaction drop, the apparent watts input must equal the output.

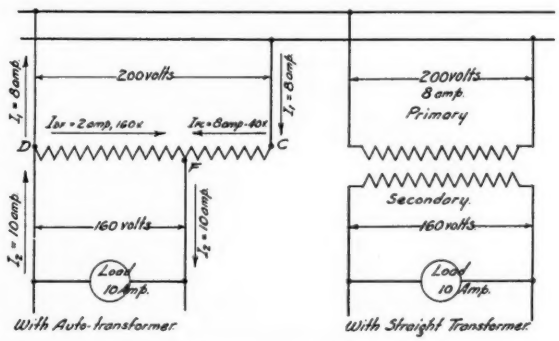


FIG. 1. DIAGRAM COMPARING RATING OF AN AUTO-TRANSFORMER WITH THAT OF A TWO-WINDING TRANSFORMER

Output = 160 v. × 10 amp. = 1600 v. amp.

Current input = $\frac{1600 \text{ va.}}{200 \text{ v.}}$ = 8 amp.

Winding CF must carry 8 amp.

Winding DF must provide the other 2 amp.

Winding CF furnishes 40 v. × 8 amp. = 320 v. amp.

Winding DF furnishes 160 v. × 2 amp. = 320 v. amp.

Thus the rating of this particular auto-transformer would be 320 v. amp., or about ⅓ kv.a. If comparison is now made with the two-winding transformer, it will be seen that for handling the same 10-amp. load with a voltage reduction of 200 to 160: the primary winding carries 8 amp. at 200 v. = 1600 v. amp., and the secondary winding carries 10 amp. at 160 v. = 1600 v. amp. This would require a transformer having a rating of about 1½ kv.a., or five times as large as the auto-transformer for the same work.

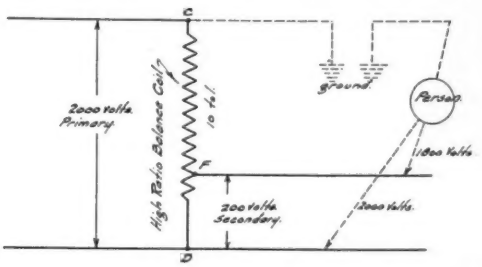


FIG. 2. SHOWING DANGEROUS EFFECT DUE TO ACCIDENTAL GROUND WITH HIGH RATIOS OF TRANSFORMATION

THE SELECTION OF AUTO-TRANSFORMERS

THE PROCEDURE involved in determining the capacity of a balance coil to conform to definite load conditions is clearly outlined in the American Electricians' Handbook. The authority mentioned states that the capacity of a balance coil for three-wire service is determined by the unbalanced load or the difference in load between the two circuits. For example, if there are 50 lights on one side of the coil and 100 on the other, the actual load on the coil is 50 lights. If there are 200 lights on one side and 150 on the other, the load on the coil is, as before, 50 lights. The kv.a. capacity of a coil represents the normal unbalancing allowable between the side circuits. The reason for this is that only the unbalanced current flows through the coil, and on this account a balance coil may be placed on a circuit supplying any

number of lights, provided that the difference in loads on the two circuits does not exceed the capacity of the coil. In selecting a three-wire balance coil, one having a capacity sufficient for supplying one-half the total number of lights on the two circuits is sometimes chosen, so that all the lights on one circuit may be turned off without overloading the coil.

Practicing engineers vary greatly in opinion regarding the size of coil properly suited to given load conditions. In industrial work, the writer has seen coils selected for unbalanced conditions ranging in capacity from 50 per cent down to 10 per cent of the total load on the two side circuits, but has learned from long experience that, in most cases, the selection and installation of a coil whose capacity is 25 per cent of the total load on the two side circuits is safe and satisfactory. In a Westinghouse publication the figure, 25 per cent, is given as a safe one to use in all cases where more definite data is lacking.

Auto-transformers for operation on 220 v. supply circuits are usually made for 110-v., two-wire, or, 110/220-v., three-wire secondaries. One prominent manufacturer lists them as auto-transformers, while another manufacturer terms them Balance Coils. Both of these manufacturers list units for operation on 25 and 60-cycle systems and schedule as stock articles, coils rated at 1, 2, 3, 5, 7½, 10 and 15-kv.a. capacities. Balance coils are housed or enclosed in banks quite similar in general appearance to those of ordinary distributing type transformers. The cases are made for convenient mountings, although the wall mounting is not recommended for size of 15 kv.a. or even 10 kv.a. if it is avoidable. The larger size should be placed on skids on the floor, much the same as regular transformers.

In most instances, the 25-cycle units are heavier than those for 60 cycles. A one kv.a. coil for either frequency of the 220 v. class weighs about 60 lb. without the coil, and a 10 kv.a. weighs 132 lb. for 60 cycles as compared with 395 lb. for a 25-cycle coil of the same capacity. The 25-cycle coils are more costly—in 1921 a 1 kv.a. coil listed at $40 as compared with a 1 kv.a. 60-cycle coil listed at $28.

Before leaving the subject of selection it is well to caution about the misuse of the word "Rating" when applied to balance coils. The kv.a. rating of an auto-transformer does not pertain to output but simply shows the size, price and losses as compared with the two-winding transformer of equal output.

The Danger of Reversal of Connections

Diagrams showing ways of using balance coil with single, two and three-phase 220-volt systems are given along with problems which are worked out as examples further on. One using balance coils is warned to exercise care to see that connections are not accidentally interchanged. If the primary and secondary were interchanged on high voltage coils, where the ratio of transformation is say 2 to 1, it is seen that a real hazard would or might exist. For instance, if the primary were 2000 v. and the secondary only tapped out for 1000 v., a 2 to 1 ratio would result. Now if, by chance, the secondary terminals were connected to the 2000-v. source, the primary would be subjected to 4000 v. The hazard is not to such a degree with low voltage like 220, although severe damage may result to life and property through incorrect connections even with this low potential.

High Ratios of Transformation

While the ordinary feeder circuits about an industrial plant seldom carry 2000 v. current, it is of interest to note one of the serious objections to balance coils wherein the ratio of transformation is high. In Fig. 1 it will be seen that an accidental ground on the high voltage side at C would establish a high voltage between the low tension leads and grounds. This might result in a dangerous shock to anyone touching the conductors on the low voltage side, or might cause other damage. The chance of accident can be lessened by grounding the common connection D. If a ground then occurs on line C, a short circuit is made which will open any protection device in the high voltage circuit connecting points C and D, provided, of course, that the resistance between the two grounded points is not great and that the protective features function.

Power Requirements for Radio Broadcasting

Numerous Factors Other Than Power Requirements Govern Range of Radio Transmission

HOW MUCH POWER is required for radio broadcasting? This is a question about which many, interested in installing broadcasting or radio transmitting stations, are curious, and about which little has been said in the general current literature on the subject.

The scope of radio is gradually being extended and at the present time is used extensively in a variety of ways. The broadcasting of news and weather reports, speeches, musical entertainment, church services, etc., is providing valuable service to hundreds of thousands of listeners. At sea, radio is of tremendous importance, not only for ship to ship, and shore to ship communication but also for position finding of vessels. Trans-Atlantic radio telegraphy has been an accomplished fact for years and today this service compares favorably with cable telegraphy.

Radio has also proved of great value to a number of power companies in the generation and distribution of electrical energy. These companies are not so much interested in the broadcasting features of radio as they are in establishing a positive means of communication between the various generating stations and sub-stations on the system. In this connection, the possibility of remote control of switches by superposition of radio frequency current on the regular power lines are of particular importance.

These power companies, as stated before, are directly concerned with the establishing of radio communication over a certain definite area. The question of the amount of power required to insure positive communication over a specified range is therefore one of the first to arise, and is one that is difficult to answer at the present time.

So many other factors influence radio transmission

that the actual amount of power used at any station is of comparatively little significance, as a means by which to estimate the power requirements for another station. The more important of these factors may be listed as follows: Height of aerial, time of day, time of year, weather or atmospheric conditions sensitiveness of receiving apparatus, local geography (mountains, sea, deserts, high steel buildings, etc.), freaks or unknown conditions.

So, while unusual success is being obtained by broadcasting stations throughout the country, the matter of installing a station with a definite minimum range of transmission is still an uncertain proposition. For short distances, say within 200 mi., no difficulty seems to be encountered and these distances can be relied upon with a reasonable amount of certainty.

Contrary to the more or less general impression that high power is required, the actual power used for radio broadcasting is small. It is true that some of the large high-power trans-oceanic stations use comparatively large quantities of power, but these stations are in a class by themselves and are not to be associated with the popular broadcasting stations of the present day.

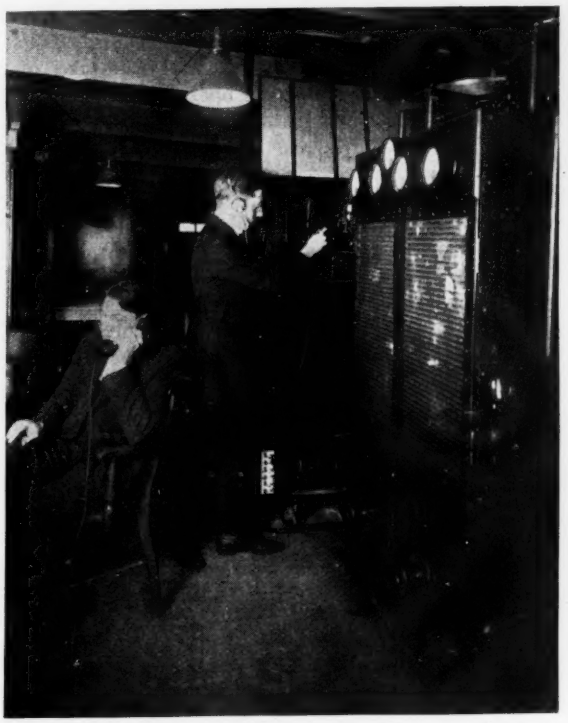


FIG. 1. TRANSMITTING APPARATUS AT KYW, THE WESTINGHOUSE BROADCASTING STATION AT CHICAGO

These trans-oceanic stations are usually designed to operate in conjunction with a similar station on the opposite side of the ocean. They are designed for 24 hr. service under practically all atmospheric conditions, and as a rule their minimum transmitting range cannot fall below 2500 or 3000 mi. A different type of transmitting apparatus is also employed in these plants from that used in the broadcasting station.

The perfection of the three-electrode vacuum tube has revolutionized radio work. It is possible to accomplish things in radio today that were entirely undreamed of a few years ago. Where a short time ago it was necessary to use kilowatts, today the same work can be done by the expenditure of only a few watts.

KDKA, the Westinghouse broadcasting station at Pittsburgh, for instance, has been heard consistently in the State of Washington, although they have been radiating only 500 w.—about the same amount of energy as is used by an ordinary household toaster. And yet, with this exceedingly small expenditure of energy, music and information was being transmitted to tens of thousands of people throughout the country.

FIG. 2. BROADCASTING STUDIO AT KYW

There are also instances where amateurs, using from 5 to 35 w., have been heard across the continent; while these are exceptional cases, and are generally regarded as freaks, they serve to indicate that there are factors affecting transmission of which we are still ignorant.

In a recent contest, 18 amateurs on the Atlantic coast using various types of transmitters with power inputs all below one kilowatt, were distinctly heard in Scotland.

These examples, while they serve to indicate the slight importance of power, as a contributing factor towards long distance transmission in some cases, cannot be relied upon and are the exception rather than the rule. Much investigation and experimentation remains to be done in this direction and until the laws governing radio transmission are more definitely understood, the installer will have to play safe and provide a greater amount of power than that which occasional long-distance records seem to warrant necessary.

The efficiency of the transmitting equipment must, of course, also be considered, as an antenna output of say 500 w. will require an input to the transmitter of about twice that amount. At KYW in Chicago, for instance, when the output to the aerial was 500 w., the input to the transmitting equipment was about 1200 w.

Transmission from the average broadcasting station is approximately four times as effective at night as it is during the day, and about two to three times as good in winter as it is in summer. It is therefore evident that a station which is only to be operated at night need not employ the same power as that required by a station

with the same range but where daylight operation is necessary.

The sensitivity of the receiving apparatus may furthermore determine to a great extent the amount of power necessary at the transmitting set. Where with the single crystal detector, signals from a certain transmitting station cannot be heard at a distance of over 100 miles, an up-to-date station with regenerative set using vacuum tubes for both radio and audio frequency amplification, will produce audible signals from this station clearly at a distance of from 1000 to 2500 mi.

There are, then, as the reader will perceive, a multitude of variable factors which govern radio transmission and the individual or company desirous of carrying on radio communication between certain points will have to expect to do considerable experimenting if he wishes to make a success of the undertaking. As stated previously, for short distances, no great difficulty need be expected and the apparatus has been fairly well standardized. For long-distance work, the variable factors will play an increasingly important part and each case will require a certain amount of individual study and experimentation.

Novel Method of Control for Automatic Hydroelectric Station

TWO 2200 KV.A. GENERATORS TO BE CONTROLLED OVER A TELEPHONE CIRCUIT FROM A POINT THREE MILES DISTANT

PROGRESS IN the development of control equipment for automatic hydroelectric generating stations is reflected in the exceedingly novel method of control which is to be installed at the Johnson Falls Development about 60 mi. north of Green Bay, Wisconsin.

This station, which is being built by the Northeastern Power Co., will consist of two 2200 kv.a. water wheel generators and will be operated over a telephone circuit from the High Falls plant about three miles away.

At this station there will be installed a dial of the type usually found in automatic telephone systems. There will also be a telephone receiver, a reversing line key, and a loud speaking telephone receiver for alarm purposes.

At the automatic generating station there will be installed a 16-v. storage battery, together with a group of selectors for performing the various operations and setting up the necessary signals for the answer back. The connection between these two will consist of a single pair of copper clad steel wires. If the operator desires to ascertain the head of water at the automatic generating station, he will dial number 11 on the automatic telephone in the usual way, that is by dialing one, allowing the dial to reset and then dialing one again. Before dialing, the line key is set to the operating position. Immediately after dialing, a single stroke bell will be heard through the telephone receiver striking two single strokes separated by a slight interval, meaning eleven, thus reporting back to the operator the fact that the selector in the automatic station has actually stopped on point No. 11. After the bell signal, the operator hears a series of buzzer notes which he counts—the largest number being ten. The total probable variation in water level is divided into ten divisions, each buzzer tone indicating one division; thus, if the water were at half the normal head, the operator would count five buzzer tones, then by adding the base height of water plus five times the amount of each step, the actual height of the water will be known. If the amount of water in the forebay is sufficient to operate one machine, the operator clears the line by opening the line key, then immediately closes it and dials No. 7 to start machine No. 1 or No. 8 to start machine No. 2.

Before the actual starting operating takes place, the single stroke bell will sound seven or eight strokes as the case may be. If the operator finds that he has gotten a different point than the one he desired, he opens the line key, thus resetting the selectors to zero and is ready to start over. If, however, the correct number of strokes are counted, the line key is left in the closed position for a few seconds and the desired machine will be started and thrown on the line. If it is desired to stop either machine, two other code numbers—nine and ten—are provided.

The automatic control is so designed as to start the machine and put it on at full gate opening. If the operator decides that the load cannot be carried with the amount of water available, he can reduce the load by dialing the proper number. For instance, if machine No. 1 has more load than can be carried, he will dial No. 3 and, upon listening, will hear three strokes of the bell, indicating that the proper operation will take place, after which the pilot motor on the governor will be operated for a few seconds. Immediately after the short period during which the governor motor operates to reduce the load, the selector is automatically connected to a code signal device by means of a series of ten buzzer tones in the same manner as the height of water is indicated, each buzzer tone indicating one tenth of the total gate opening. If the load has not been reduced by a sufficient amount, the line key is opened and closed and the same number dialed again, upon which the same sequence will be obtained and the load will be reduced still further. If the load is reduced too much, another number, in this case No. 1, for increasing the load on machine No. 1 will be dialed with the same result as before, except that the load is increased instead of decreased. Another pair of numbers—5 and 6—are provided if it is desired only to read the gate opening on either of the two machines without causing any change in the load.

DETERMINING CAUSE OF TROUBLE

IN CASE anything happens in the automatic station of an abnormal character, such as the machine shutting down on overload or locking out for any reason, a high pitched warning tone is put onto the telephone line and sounds to the operator from the loud speaking receiver. To stop the operation of this signal, another number, 12, is provided. If, after the operation of the warning signal, it is desired to ascertain what has caused its operation, a number, 13, is provided which will connect in the circuit a slow motion selector which will test each safety device in succession on the two machines. The operator keeps track of the number of operations and recognizes the condition by the tone of the signal. A low pitched buzzer signal will indicate normal operation, while a very shrill, high pitched tone will indicate trouble. By counting the number of indications given,

the number of the particular step which gives the abnormal signal can be ascertained and then, by consulting the reference list, the actual piece of apparatus in trouble can be identified by the operator, so that in notifying the maintenance man of the trouble, he can also tell him exactly where to look for it. If, for instance, the station is in full operation and number two machine should get hot bearings and shut down, the warning signal would be put on the line. The operator would immediately dial No. 13 and listen in on the receiver. Assuming that the bearing thermostat on machine No. 2 is assigned No. 10 on the list of apparatus, the operator would count from one to nine low toned buzzer signals but at the tenth signal would hear a high pitched buzzer tone. Referring to his list he would see that this indicated bearing thermostat trouble and would immediately send a maintenance man, properly equipped, to the station to investigate the oiling system and bearings of machine No. 2.

This control system has been developed by the Westinghouse Electric & Manufacturing Co., and is the first installation to be put into actual service.

The Commutator

By J. B. Dillon

VOLUMES have been written pro and con relative to the underslotting of commutators, yet today there are many well versed people, for and against the idea. It is not the purpose here to enter into a discussion of the merits or demerits, generally, but to mention a specific case.

It was a 7-v. motor-generator, that is, 220 v. on the motor end and 7 v. supposed to be given out as the normal voltage at the generator end. A speedometer showed that the speed was all there; no coils were cut out of the armature deliberately, that is, yet the voltage would not reach 7, varying from 5.5 to 6.5. Both metal and carbon brushes were tried, the preference being for wire gauze brushes, owing to the fact that 3.5 amp. were required, the carbon heating too much, still the varying electromotive force precluded the necessary current.

There were no ruts on the commutator, nor any visible high mica bars in so far as the "experts" could see or feel.

The generator was a compound one, the cutting in of resistance at the shunt rheostat lowering the electromotive force, but cutting it all out would not bring the voltage out of the variable 5.5 to 6.5.

The regular attendant, rubbing his oily hands within his blonde locks, said: "Well, we got to do something. I know that she gave out the full 7 v. up to 30 days ago and I also know that I get 7 v. from the extra armature which is at present in the shop."

A newcomer who was merely an onlooker, said: "Why not underslot her?"

"Do you think there is anything to that?"

"Yes, and anyway it is a cinch that it will do no harm to try it."

Within a few minutes the job was completed and up she went to 7.5 v., and it was necessary to insert some resistance at the shunt rheostat.

What's the answer? That regardless of all tests made there was a high mica bar, or the centrifugal force would cause a short between coils due to metallic dust between the commutator bars.

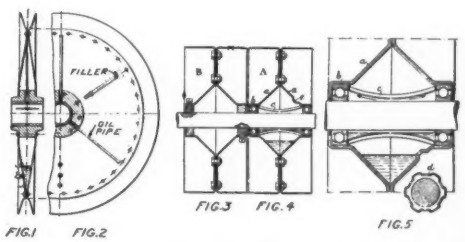
The underslotting would of course remove both troubles and by brushing out the "underslot" occasionally, dust shorts would be prevented.

This is a true report of a particular case; hence, if you have a generator acting mulish along the lines mentioned, try underslotting.

Pulleys with Automatic Lubrication

By J. H. Blakey

THE FRENCH house of Stothert et Pitt, which manufactures cranes and hoisting appliances, has designed a pulley with automatic lubrication, for use more especially in those parts of cranes which are difficult of access. Figures 1 and 2 show a section and half elevation of the Lawrence pulley. It is made of two stamped sections, of sheet steel. The hub is of cast iron, with a lining of bronze or other suitable material.



FIGS. 1 AND 2. SECTION AND ELEVATION OF LAWRENCE SELF-OILING PULLEY

FIGS. 3 AND 4. SECTIONS OF FIXED AND LOOSE STAMPED STEEL PULLEYS

FIG. 5. DETAILS OF MEANS FOR AUTOMATIC OILING

The sections are riveted together and soldered electrically. In one section is a filling pipe, and into the hub run three radial tubes of such length as to reach the circumference of the interior cavity. This cavity may be filled with oil, which can reach the pulley shaft only when it is in motion. These pulleys have been in use at the docks of a number of French and English seaports for over a year without refilling.

Another self-lubricating pulley, made by La Compagnie d'Applicacions Mecaniques, is designed as a loose pulley to run on ball bearings. This also is composed of two stamped sections, and the central part of the interior cavity is occupied by a sleeve of thin plate, having a certain amount of elasticity. This holds the ball bearings in position while the two sections are being assembled. At its smallest diameter it is grooved, and each groove has an oil hole into which the oil dripping from the conical faces of the reservoir finds its way when the pulley is at rest. This oil, when the pulley moves, is driven by centrifugal action into the ball bearings.

Adding a dollar or five dollars a week to his pay envelope will not make a workman into a plant manager. But adding a book or a good technical journal to his equipment may help him to develop into a first rate manager, and his pay will take care of itself.

Queenston-Chippawa Development

NIAGARA'S LATEST HYDROELECTRIC POWER PLANT

CENTERED around Niagara Falls are the greatest hydroelectric power plants the world has known. For more than the past century the hydraulic plants on the Niagara River have represented the very latest designs of hydraulic equipment. Each new plant contained features which were used there for the first time as an industrial application. The latest power development at Niagara again outclasses other hydroelectric plants in many respects and its special features

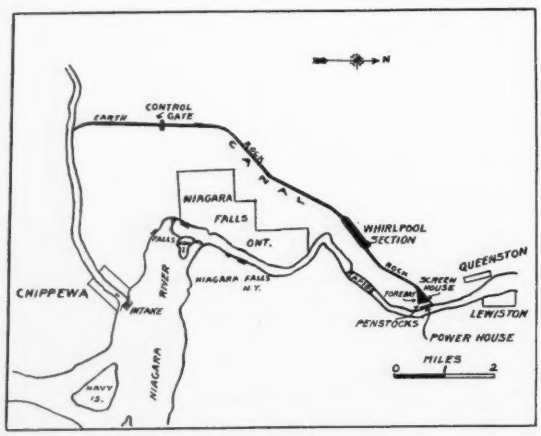


FIG. 1. MAP OF DEVELOPMENT

will quite likely be used as patterns in many future developments throughout the world.

This most recent work is known as the Queenston Chippawa Development and is due to the enterprise of the Hydro-Electric Power Commission of Ontario. The general plan of this development was described in the Nov. 1, 1919, issue of Power Plant Engineering but as the plant was put into operation last December the outstanding details were only recently made public in papers presented at the convention of the American Institute of Electrical Engineers from which the information given in the following description has been taken.

Between Lake Erie and Lake Ontario there is a total fall of 327 ft. of which previous developments around Niagara have utilized 130 to 210 ft. with widely different degrees of efficiency, the Queenston-Chippawa Development, however, has an operating head of 305 ft. The conservation of head effective by reduction of hydraulic losses to a minimum, and by refinements in the design of the various essential elements of the project as a whole, has resulted in the production of a power development which is believed to represent the best in modern engineering practice.

Water is taken from the Niagara River about one mile above the falls, is conveyed through an improved section of the Welland River a distance of 4½ mi., thence by a canal 8½ mi. long, to the forebay and screen house located on the Niagara River about one mile south of the village of Queenston. From the screen house steel penstocks encased in concrete carry the water down the cliff to the power house from which it passes to the Niagara River.

That part of the plant now in operation and in course of construction consists of five 45,000-kv.a., 187.5 r.p.m. units generating power at 12,000 v., three phase, 25 cycles, which in turn is transformed to 110,000 v. for transmission. Ultimately the plant will consist of nine or ten units, with a capacity of 575,000 to 650,000 hp. The subsequent units, in all probability, will have greater capacity than those being installed at present. Two of the units are now in service developing 110,000 hp. which is being delivered to the existing 110,000-v. system at Niagara Falls for transmission to Toronto, London and Windsor, Sarnia and intermediate municipalities.

CANAL INTAKE

ONE OF the great obstacles to continuity of service is the ice which passes down the Niagara River. The site of the intake of the Queenston-Chippawa development is favorable in that floating ice does not ordinarily follow the shore line at this point; but the smooth gradient of the river surface and the comparatively shallow water with its low velocity is unfavorable.

To solve the problem presented in this particular instance, large size models were constructed duplicating

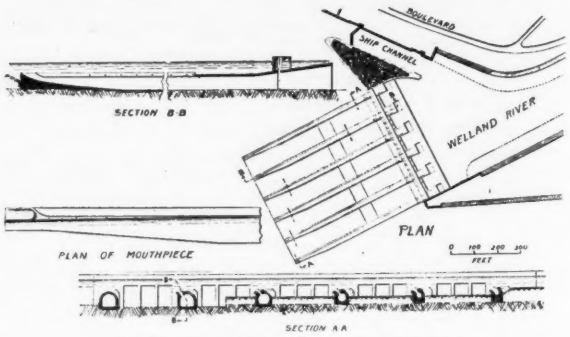


FIG. 2. INTAKE PLAN AND SECTIONS

to scale the topographical conditions existing, and from experiments with these models and other data available the design shown in Fig. 2 was developed which, it is confidently expected, will operate in such a way as to keep the plant wholly free from this ice menace.

The intake structure is made up of an entrance with lock gates for navigation, a bulkhead section, and the intake proper, the latter combining two forms of intake; the conventional or surface intake consisting of a concrete barrier or boom with 15 openings each 18 ft. wide normally having 8 ft. of submergence which can be increased by means of drop gates to an amount up to the full depth of the water or 35 ft.; and the submerged intake consisting of gathering tubes or draft distributors, six in number and 675 ft. in length. Water enters the tubes along a distance of 500 ft. through a slot on their up stream sides. These tubes are controlled by gates similar to those on the surface intake and comprise an outer tapering section, wherein the velocity is maintained constant, with a longer inner section of 20-ft.

diameter, wherein the velocity regularly increases with respect to distance along the axis. Diffuser sections are situated at the inner end to reduce the velocity to that existing in the Welland River section with as little loss as possible.

One of the features of the canal is the concrete lining which was prompted by economic considerations. The height of the lining was fixed slightly lower than the profile of the water surface existing when the load conditions on the plant are a maximum and the Niagara River flow is a minimum. The thickness of the lining averaged about 20 in. and where necessary steel dowels were used to anchor the concrete lining to the rock face. It was held that extreme smoothness of surface was not the only determining factor but the precise alinement is also a most important element in the reduction of hydraulic losses.

Near the beginning of the rock section, which is about a mile from the Welland River, is located a control gate which is an electrically operated Stony sluice of 48-ft. clear span the full width of the rock section. The gate, which is supported on steel towers with a concrete substructure, weighs approximately 100 T. and is provided with two hoisting mechanisms and two counterweights. When in its uppermost position the gate will permit the passage of a tug beneath it.

Bowman's Ravine just west of the whirlpool is thought to be an old river channel through which Niagara River in preglacial times flowed toward Lake Ontario. The ravine crossing was made on a rock fill, the canal cross-section being changed from a 48-ft. rectangular section to a trapezoidal section with 10-ft. bottom width and side slopes of one vertical and one-half-to-one horizontal. This cross-section was designed to be as large as the rock section at the extreme minimum water level at which operation of the generating station could take place, and of course the trapezoidal shape gives it greater area than the rectangular for any water surface elevation greater than this. The whirlpool section is lined with concrete, carrying considerable reinforcement to protect the lining, in the event of settlement of the fill. It was also anticipated that should the canal be emptied at any future time, this lining would not withstand the inward pressure of the water with which the supporting rock fill would be saturated, so vents of sufficient size to drain the fill as quickly as the water could be drawn down in the canal, were provided near the top and bottom of the channel. These vents are protected with light wooden covers, which will be dislodged under a comparatively small excess of inward pressure.

In the design of the forebay provision was made for reducing the velocity of the water in such a way as to reclaim the kinetic energy as the water leaves the canal. After rather exhaustive experiments with a model of the forebay a 10-deg. angle of flare proved to be the most efficient in converting this energy so as to give the greatest head on the turbines. The experiments resulted in the design of the diffuser structure inserted in the forebay transition, providing two entrance passages into the forebay each with a diverging angle of 10 deg. It consists of a wedge shaped structure 221 ft. long and 37 ft. wide at the downstream end. The sides are vertical, straight and smooth and are carried 28 ft. above the bottom of the forebay. An opening 16 ft. by 20 ft. in the end of the wall assures approximately equal pressures on both sides of the walls Through this expedient, for a flow of 15,000 cu. ft. per sec., and mean water level at Chippawa, the reclaimed head amounts to approximately 1 ft.

Extending across the bottom of the forebay immediately in front of the screen house piers is a trash trench of liberal dimensions used to collect any debris or foreign material which may travel along the bottom of the forebay. An opening in the main floor immediately behind the racks provides a means of disposal of trash into a trough which empties into the ice chute.

The screen house, as constructed, provides for nine main units, a service unit and an ice chute, and is arranged so that a further unit may be added at the north end.

The entrance to each of the main penstocks is a modified bellmouth consisting of three openings 12 ft. 8 in. wide and 29 ft. high at the rack supports. These three openings gradually converge into one opening 16 ft. in diameter at the point of connection to the penstocks. The bellmouth entrances are sealed by a concrete curtain wall immediately behind which steel lined

FIG. 3. CANAL AT WHIRLPOOL SECTION

gate checks are provided to support structural steel gates. These provide a means for unwatering. The racks, which consist of 3 by ⅜-in. bars on edge, at 5-in. centers, are fastened rigidly to a structural steel supporting frame.

The ice chute bay has a clear width of 25 ft. and is provided with a sluice gate which is lowered to pass surface water carrying ice. The water and ice are carried down the cliff in a 10-ft. diameter concrete pipe and discharge into the river.

From the screen house, the water is carried to the turbines in steel plate penstocks 16 ft. in diameter for two-thirds of their length then tapering down to 14 ft. The penstocks have only two bends, one at the top and one at the bottom, both elbows being held in massive concrete anchor blocks. In the design of the penstocks a stress of 12,000 lb. to the inch was used, this figure being taken to provide for exigencies of corrosion, fatigue, suddenly applied loads and other indeterminate or unknown contingencies. The thickness of the plates varies from ½ in. at the top to 1¼ in. at the bottom. The penstocks are covered throughout their entire length

with a concrete envelope having a minimum thickness of 24 in.

Generating and Transformer Station

The generating and transformer station (Fig. 4) is located below the escarpment and close to the river's edge. The structure required to house five main units and the service equipment is 350 ft. long, and ultimately this length will be doubled. The substructure is of massive concrete construction carried down to rock foundations, and provides chambers and tunnels for housing and giving access to various kinds of apparatus. The superstructure consists of a structural steel frame work

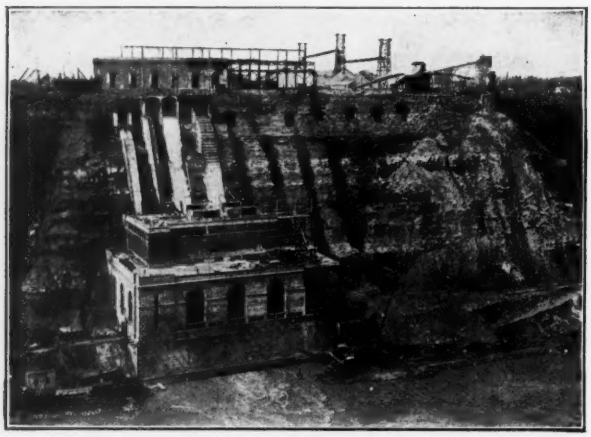


FIG. 4. POWER HOUSE AS VIEWED FROM AMERICAN SIDE OF RIVER

with reinforced concrete floors and roofs, and concrete, brick and tile walls and partitions.

It will be noted from the cross-section of the plant (Fig. 5) that the layout of electrical equipment accommodates itself to the 60-deg. slope of the cliff.

The illustrations show the general design of the building. Some features which may be mentioned are: the arrangement of the generator cooling air intake ducts, which are carried up in the east wall between the columns to above elevation 300, where openings are provided to admit air either from outdoors, or from the interior of the generator room, an arrangement which takes up no floor space; the location of the generator room main floor at the top of the generator frame, a construction which provides space at small cost for the exhaust air ducts, fans, generator field equipment adjacent to the unit, and still allows a clear space around the generator on the main floor; the large steel sash windows in the generator room which are 21 ft. in width by a total height of 38 ft. 4 in.; longitudinal tunnels in the substructure for handling turbine runners, and for piping; a longitudinal room, centrally located, for all conduit runs for control and instrument cable, with a corridor immediately above it the full length of the building; the location of control room over generator room at the center of the completed plant; provision of separate rooms for each 12-kv. oil circuit breaker; and particularly the symmetrical location of all main equipment for each unit—governors, transformers, oil circuit breakers, reactors, fans—in the 50-ft. longitudinal space in which the turbine and its generator are situated.

Turbines

Each unit has a capacity of 55,000 brake hp. under 305-ft. head and the section through the power house shows clearly the general arrangement. The draft tube on No. 1 unit is of the common curved type modified at the elbow, while each of the other units is equipped with a Moody spreading tube. In the design of these units care was taken to insure good lubrication for the gate stems and to assure that all wearing surfaces were well greased. The use of labyrinth seals on the runner rims cuts down leakage to a minimum. The top portions of the draft tubes are of cast iron and these are so arranged that they can be lowered to facilitate the removal of the runner from below, thus dispensing with the necessity of dismantling of the generator. Owing to the presence of a considerable amount of sand in the water during periods of flood, and by reason of dredging operations in the upper canal, a pressure sand filtering plant has been installed to filter all water supplied to the lignum-vitae bearings to prevent scoring of the turbine shaft.

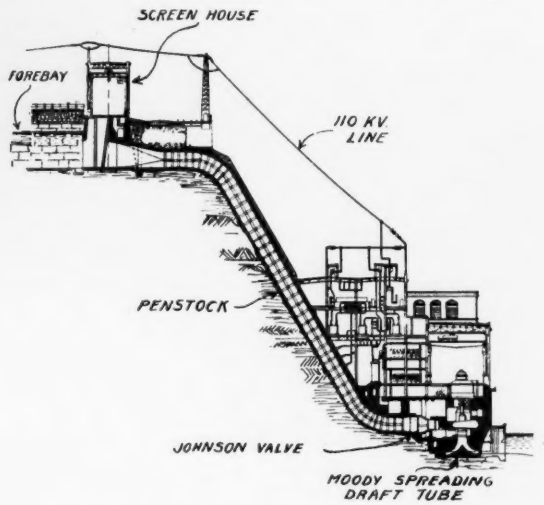


FIG. 5. CROSS-SECTION OF POWER HOUSE AND CENTER LINE OF MAIN UNIT

The lignum-vitae bearings themselves are about 6 ft. in length and in order to ensure lubrication over their entire length the water is admitted both at the middle and top of the bearing. A flow meter, with an indicator and an alarm light, is connected to the bearing water supply to guard against any stoppage of the flow continuing long enough to injure the shaft or bearing.

Air brakes, which act against the underside of the generator rotor, are provided to bring the unit to rest quickly in case of shut down.

Johnson Valves

The lower end of the main penstock terminates in a 14-ft. Johnson valve, the outlet end of which is 10 ft. in diameter and connects to the turbine casing by several sections of cast steel pipe. The method of control is accomplished through three 8-in. Johnson valves, which are in turn operated by pistons in cylinders under penstock pressure controlled by a three-way plug

valve. When opening the valve to fill the scroll case, it is necessary to build up the pressure in the latter, in order to balance the pressure on the two sides of the plunger. The operation of the valve is so arranged that this is carried out automatically by a series of oscillations of the plunger, as soon as the control handle has been thrown into the opening position. In closing, the motion of the plunger is retarded near the end of the stroke to prevent an excess rise in pressure, due to too sudden closing, and also to protect the plunger seat against shock. The control is so arranged that the valve will close automatically in case of a break in the scroll case, and it is also provided with a remote hand control so that it may be closed, if necessary, from the control pedestal on the main operating floor.

Governors

The governor system for the main units uses filtered water containing one per cent of soluble oil. This is

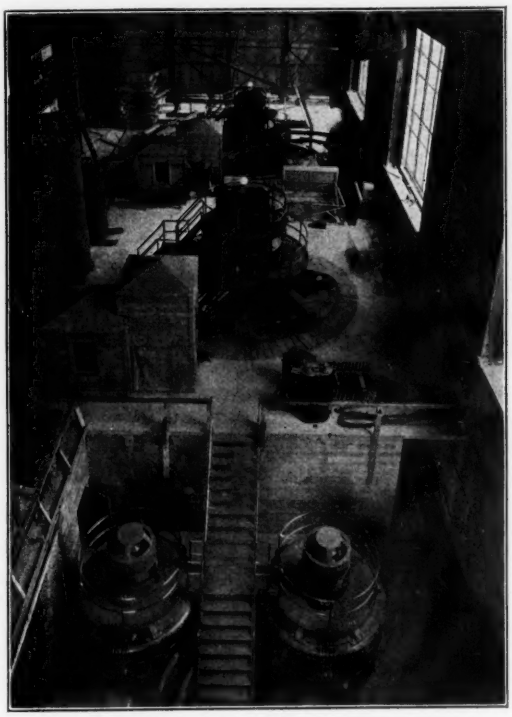


FIG. 6. GENERATOR ROOM LOOKING NORTH

supplied to the governor at from 150 to 200 lb. per sq. in. pressure from two motor-driven centrifugal pumps which feed into an accumulator tank for each unit. The return fluid from the servomotors is carried back through a return main to two concrete tanks so arranged that one tank may be emptied and cleaned while the other is in operation. It had been found in other installations, where a central pumping system capable of handling the completed plant was initially operated to supply one or two units, that difficulty was experienced owing to the large capacity pumps heating up the small amount of fluid in circulation. To avoid this, a small capacity pump was also installed to supply governor pressure during the early stages of operation, and to be held afterwards in reserve for an emergency. To guard against a shutdown due to the failure of the governor pumps, an emergency connection has been provided to pass direct penstock pressure into the governor system header. This permits the governors to operate on penstock pressure, at any time that the pumping system is out of service, and has already been called into service since the first two units were placed in operation.

The 45,000-kv.a. Generating Units

Of the five 45,000-kv.a. generating units included in the present plans at Queenston, three (Nos. 1, 2, and 3) are of Canadian Westinghouse Co. manufacture, while the remaining two (Nos. 4 and 5) are products of the Canadian General Electric Co., Ltd. These

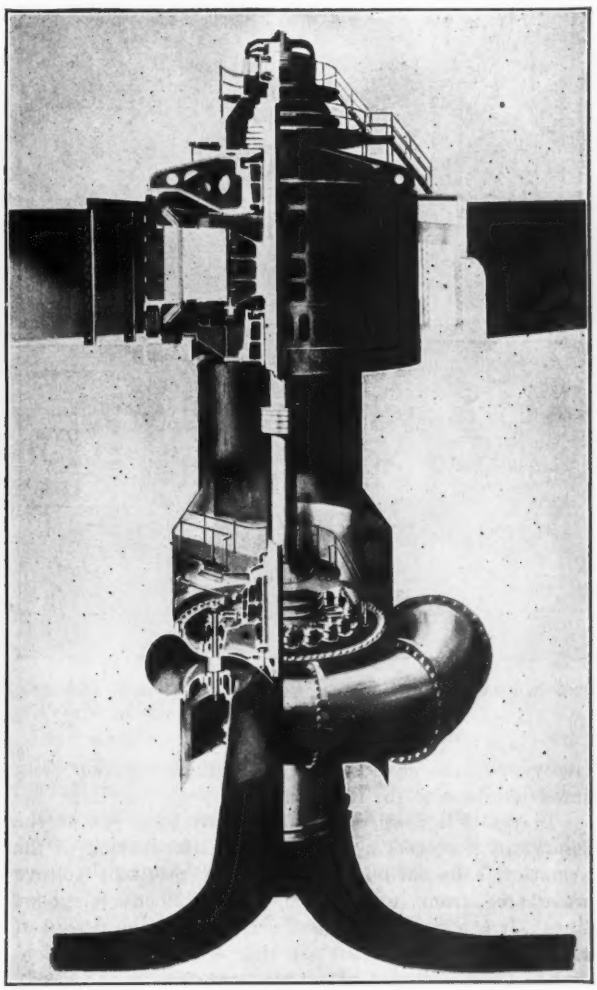


FIG. 7. QUARTER SECTION OF WESTINGHOUSE GENERATOR WITH TURBINE

units, as far as records show, are the largest hydroelectric generators ever built and put into service.

The five machines are all of equal rated capacity but being of different manufacture, the constructional features of the two makes of machines are somewhat different from each other. The Westinghouse units, for example, have rotors with cast steel spiders and laminated, built-up sheet steel rims dovetailed to the spider. The General Electric units, on the other hand, have rotors made up of seven cast steel sections, five of which carry the pole pieces. In describing the general features

of the generators it will, therefore, be convenient to take up each make separately.

The Westinghouse Units

The two Westinghouse units in the initial installation are each rated at 45,000 kv.a., 12,000 v., 80 per cent power factor, three phase, 25 cycles, 187½ r.p.m., nominal, or 49,500 kv.a., 13,200 v. maximum. A third duplicate unit will shortly follow the first two machines.

On account of their size, both in kilovolt-ampere rating and in physical proportions, some interesting design problems were raised. Figure 7 gives a perspective view of the generator unit, in quarter section, with some details as to the turbine.

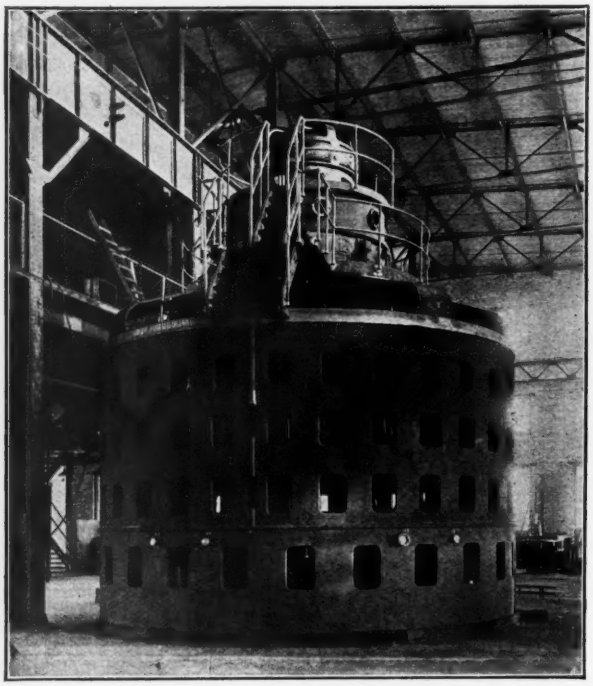


FIG. 8. GENERAL VIEW OF ASSEMBLED GENERAL ELECTRIC CO. UNIT

In the design of the armature winding, one of the important problems was to obtain a distribution of the armature coils such as to produce a resultant voltage wave free from interference with adjacent telephone lines. It is a well understood condition in the design of electrical generators that starting with the usual field flux form, the actual resultant wave will more nearly follow the desired law, other factors being the same, provided that the conductors, producing the resultant wave, are distributed at a maximum number of different positions about the armature periphery; i. e., the maximum number of slots. In the design of the Queenston machines, it was not found possible to use an actual number of slots sufficiently large to insure the desired results; however, the same effect was obtained by employing instead of the usual whole number of slots per pole, a fractional number of slots per pole. The design selected had 19½ slots per pole which gave a distribution of the winding equivalent to 39 slots per pole.

To support the end windings as to enable them to resist the enormous stresses that would be set up under short circuit conditions, the coil ends were bent away from the air gap at an angle of about 45 deg. to provide space below the boreline for the clamping blocks. The coil ends were braced against distortion by clamping them with through bolts between parallel insulating blocks which are bolted to angle-shaped brackets attached to the frame.

In designing the rotating spider, the particular problem was to select a construction in which the material throughout would be of uniform quality. The "laminated rim" type of design was therefore adopted as the one best suited to meet the requirements. The design used an inner cast steel spider which consists of a hub and arms but has no rim. The rim is built up using over-lapping 1/16-in. rolled steel plates that are dovetailed to the spider arms in a manner similar to that used in attaching the armature punching to the frame.

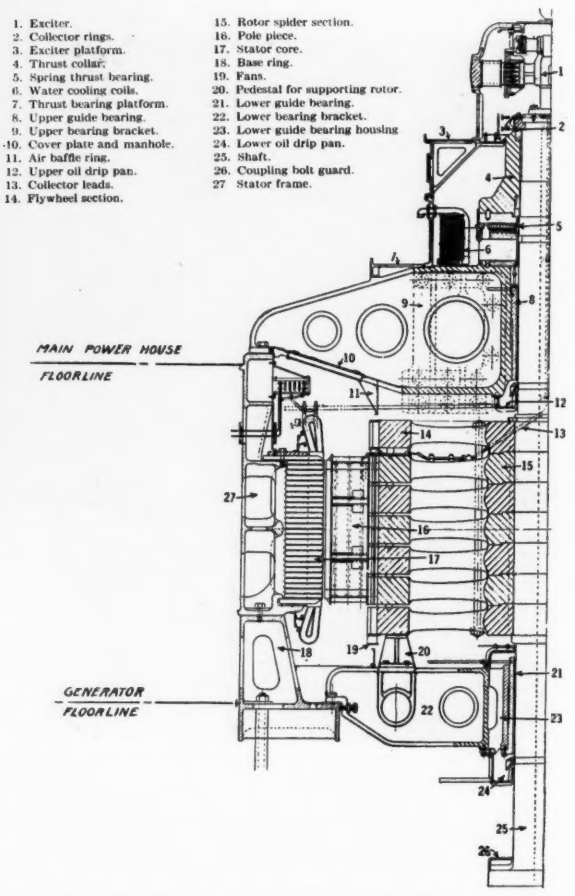


FIG. 9. COMPLETE ASSEMBLY SECTION OF G. E. UNIT

In addition to being attached to the spider by the dovetails, the rim is clamped between heavy steel end plates by means of through bolts that pass through the entire laminated rim and the end plates. In this design the rim was not only self supporting as to radial stresses, entirely neglecting the dovetails, but was also capable of carrying the weight of the poles and field coils when operating at a maximum speed of 347 r.p.m.

The principal dimensions and weights of the generators are as follows:

Maximum over-all diameter.....25 ft.
Height from floor line to top of frame.....13 ft., 8 in.
Maximum over-all height from floor line..26 ft., 10 in.
Diameter of shaft at coupling.....2 ft., 6 in.
Total weight of copper.....50,000 lb.
Weight of rotating part.....615,000 lb.
Total weight of generator unit.....1,400,000 lb.
Load on thrust bearing.....1,000,000 lb.
Flywheel effect of rotor.....21,500,000 lb. ft.^{2}

The General Electric Co. Units

Because of the fact that the rated capacity of these generators is greater than that of any generators ever before constructed, there is a tendency to create an impression that their construction would involve radical changes from the more or less familiar types of much smaller generators, but aside from one or two requirements peculiar to this installation, the problems presented in the design of these generators involved no great difficulties or departure from what has been considered standard construction.

The machines are rated at 45,000 kv.a., 80 per cent power factor, 12,000 v., 25 cycles, three phase, 187½ r.p.m. with a temperature rise not exceeding 65 deg. C. The full load efficiency is guaranteed to be not less than 97¾ per cent at 100 per cent power factor. The exciters are rated at 150 kw. at 250 v.

The stator coils are chorded to take advantage of fractional pitch properties in obtaining a voltage wave form as near as possible to the ideal sine wave, and to eliminate the objectionable harmonics.

The stator winding is of the common "Barrel" type with two coils sides per slot. Each turn of the coils is insulated with mica tape applied by hand after the coil has been formed. The coil insulation consists of mica tape put on by hand with a special compound sticker between layers. This process results in a uniform insulation on the full length of the coil and when slightly heated a sufficient flexibility is obtained to permit the removal and assembly of coils without great damage to the insulation. The projecting ends of the coils at both top and bottom are braced against one another by small modern spacers, placed between the sides of the coils, and the whole winding supported at each end, against the distorting effect of short circuits by two complete steel rings which are supported from the frame by suitable iron brackets. The windings are bound securely to the supporting rings with treated cord.

To meet the requirements of the hydraulic equipment in regard to speed regulation under conditions of sudden changes in load, the rotor was required to have a much larger flywheel effect than would have been obtained if the rotor were designed with reference only to the strength required. A limited amount of this flywheel effect was available in the pole pieces with their coils, and the balance had to be obtained principally in the rim of the rotor spider. Therefore, the unusual arrangement was adopted of providing two independent spiders or flywheels mounted on the shaft, one at each end of the rotor spider proper. These flywheels are of the same diameter as the rotor spider in order to allow for the assembly of the pole pieces. The rotor spider is sectionalized into five wheels so that the complete rotor with the flywheels consists of seven separate wheels which are mounted on the shaft, one above the other. The hubs of these wheels are slightly wider than the rims so that openings are left between the rims to allow air to pass through to the spaces between the pole pieces. The construction is clearly shown in Fig. 9.

The field coils are probably the largest ever made. Each coil is wound from a continuous strip of copper 1100 ft. in length and weighing 2600 lb.

The pole pieces are of the usual construction having ⅛-in. punching riveted together between heavy cast steel end plates. Each pole with its coil weighs five tons and the peripheral velocity of the pole face at normal speed is over two miles per minute.

The shaft is 30 in. in diameter in the bearings and has a solid forged coupling. In order to insure ample stiffness of the shaft, the critical speed with the rotor and shaft in a horizontal position was kept well above the runaway speed of the water wheel.

Air for cooling the generator is admitted to the pit beneath it, through ducts from outside the station, or from the generator room and is drawn into the machine by the blower action of the rotor. The air is expelled through the openings in the stator frame into a chamber surrounding the generator and is then exhausted by a fan through a ventilating shaft through the roof or to the different parts of the power house as desired. Because of the large volume of air required (about 120,000 cu. ft. per min.) it was necessary to give special consideration to the ventilation in the construction of the power house.

The following weights and dimensions may assist in formulating a conception of the size and proportions of these generators.

Outside diameter of stator frame.....24 ft., 6 in.
Over-all height from face of coupling to top of exciter.....33 ft., 10 in.
Over-all height from base ring.....28 ft., 3 in.
Weight of stator with core and windings.....175 T.
Diameter of shaft in rotor.....32 in.
Length of shaft.....30 ft.
Weight of shaft.....40 T.
Load on thrust bearing.....500 T.
Total weight of rotor.....310 T.
Total weight of generator with exciter.....625 T.
65 mi. of wire used in one set of stator coils.
450 mi. of tape used to insulate one set of stator coils.
4 T. of cooling air required per minute.

Features of Main Transformers

The main step up transformers are of particular interest because of their great physical size and the heavy short circuit currents they are designed for. Physically they are the largest single-phase transformers in operation today. In spite of the fact that they are for 25-cycle service, even their kv.a. rating is exceeded by only one bank of single-phase transformers now in operation, namely, the 70,000 kv.a., 60-cycle bank at the Colfax station of the Duquesne Light Co.

A few statistics as to the physical size of these units might be of interest. They have a nominal rating of 15,000-kv.a. output at 80 per cent power factor delivered at 63,500 v. with 12,000 v. impressed. To compensate for the drop through the transformers under the above load condition, the open circuit voltage is 67,200 v. They have a maximum rating of 16,500 kv.a.

under the same conditions of loading as given above with a guarantee of 55 deg. C. rise in temperature.

They are operated in banks of three, delta connected on the low voltage side, star connected on the high voltage side, to step up the generated power from a nominal voltage of 12,000 to transmission line potential. Taps are provided on the high voltage side so that the line potential may be varied between 110,000 to 132,000 v.

The windings contain over 11,000 lb. of copper and the magnetic core contains over 60,000 lb. of punchings. The bare transformer weighs 99,000 lb. The case, cover, base and various accessories weigh 46,500 lb. Complete with oil, the unit weighs 205,500 lb.

The case is a cylindrical boiler plate shell, 9 ft. 6 in. outside diameter, and stands 21 ft. from the rail to the flange at the top. The height from the rail to the top of the high voltage terminal is slightly over 28 ft. The great height of the transformer is partly on account of

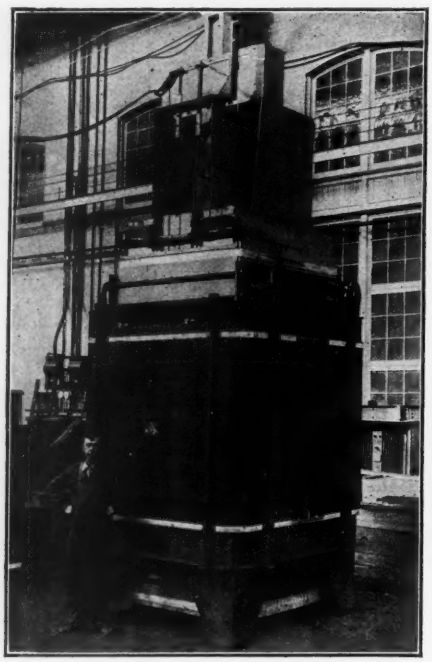


FIG. 10. ASSEMBLED VIEW OF TRANSFORMER CORE

the crowned cover and bottom which are necessary to meet the requirement of 150 lb. per sq. in. pressure, or 24 in. of vacuum, test on tank.

Each core was shipped complete as shown in Fig. 10 except that the terminal supports were removed. The winding and insulation having been thoroughly dried and treated at the factory, the cores were sealed in oil in a special shipping tank. At Queenston the cores were transferred directly to the main tanks and flooded with oil. This procedure obviated the necessity of any drying and treating of the windings or insulation after installation, furthermore it greatly reduced the time required to put the units into actual service.

Interleaved type of construction is employed with rectangular pancake coils forming the alternating group of primary and secondary coils. The individual coils are braced by the use of specially designed spacing strips. The vertical portions are supported by "wavy" spacing strips which support each turn at frequent intervals without blanketing any portion of the coil. The wavy strips are cleated together and the corners and ends of the coils are braced by means of ventilated spacers. In spite of the substantial construction used, the factors of ventilation and insulation have not been impaired in the least.

Main Connection Diagram

THE MAIN wiring diagram (Fig. 11) shows the electrical arrangement of the main apparatus. A generator, bank of transformers and a line is considered a unit, each with a normal capacity of 45,000 kv.a. It will be impracticable to dispose of the power in blocks of this capacity and grouping of units will be essential. For this purpose 12,000 v. and 110,000 v. busses are provided. The diagram shows a 12,000 v. bus, only one of which, however, that with reactors, is being installed, but space is being provided for the second or emergency bus, and this may be installed later if conditions warrant.

After studies of short-circuit values it was decided to install 5 per cent bus reactors between the generators and increase the spacing between the busses to 48 in. in order to reduce the short-circuit currents and mechanical forces to a minimum within the limits of available

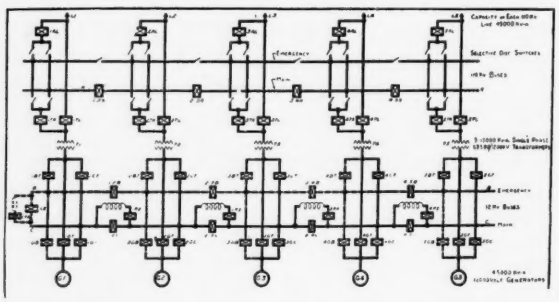


FIG. 11. WIRING DIAGRAM OF MAIN CONNECTIONS

space. Further increase in the reactance between generators would cause but slight reduction in the short-circuit currents.

These studies also gave a basis for deciding upon the strength of bus supports to use and the rupturing capacity of the oil circuit breakers required.

Oil Circuit Breakers

OIL CIRCUIT breakers for 12-kv. service are rated at 15-kv., 3000-amp. continuous capacity. These are of two types, but the structural steel supports and general dimensions are such that they may be readily interchanged.

Oil circuit breakers for 110-kv. service are rated at 135-kv., 600-amp. continuous capacity. They are of the solenoid-operated type with one tank per pole of heavy construction.

Disconnecting switches of 3000-amp. capacity (Fig. 12) are provided on each side of every oil circuit breaker and are located in separate rooms behind the breakers. They are arranged to be operated in sets of three by a hand-operated mechanism with hand wheel outside of the room in which the disconnecting switches are mounted. These mechanisms are locked in the open or closed position by individual Yale locks with master keys for the

station. The blades of the switches are locked in the closed position by the operating mechanism. Pilot lamps mounted beside the hand-operating mechanism indicate the position of the switches and whether the oil circuit breakers are open or closed.

The simplicity of the main connections in the plant and especially the absence of 12,000 v. feeders makes it possible to use differential relay schemes for protection of apparatus and connections. This allows rapid automatic removal of defective equipment from service with a minimum of disturbance to operation.

Reactors

Reactors are installed only between 12,000 v. main bus sections, i. e., between generators. They are of the cast in concrete type with the conductors and the concrete impregnated with varnish. The continuous current-carrying capacity is 2380 amp. with a temperature rise not exceeding 80 deg. C. above 40 deg. C. ambient

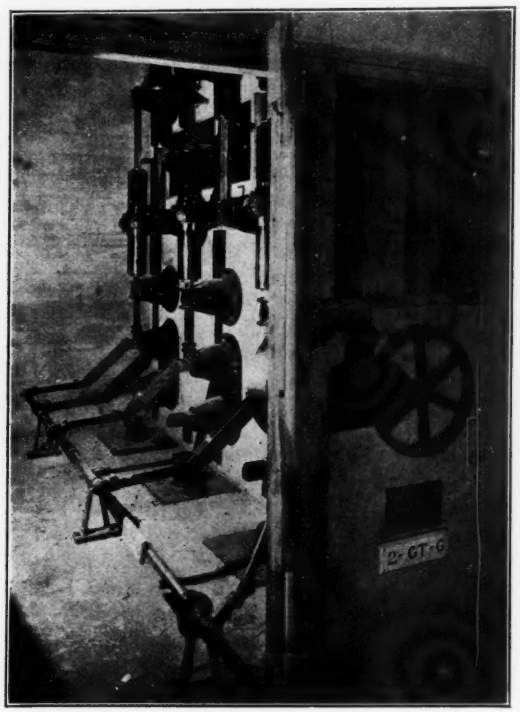


FIG. 12. 1200-V. DISCONNECTING SWITCHES WITH OPERATING MECHANISM

temperature. They will safely carry short-circuit current for 12 sec. The rating is 12,000 v., 25 cycles, single-phase 5 per cent reactance based on 2165 amp., the normal rated current of one 45,000-kv.a. generator. Protective resistors are mounted within the reactor and connected to its terminals.

Service Turbines

All services except oil switch control and signal lamps are 25-cycle operated. Power is obtained from two turbine-driven three-phase service generators each rated at 2200 kv.a., 2300 v., 25 cycles, 500 r.p.m. In addition, power for service is available from a 12,000 v. line from the Ontario Power Co.

These service turbines are rated at 2800 hp. each at 500 r.p.m. under 305 ft. head. On these units, the governors, governor pumps, etc., are entirely independent of the main governor system. Oil is used as a medium in these governors, and is supplied by two gear pumps with motors mounted on the same base as the pressure tank.

110-Kv. Outgoing Circuits

The 110-kv. circuit on each unit is brought out of the building through pent houses on the roof by means of compound-filled porcelain bushings. Oxide-film lightning arresters are installed indoors on each unit.

The single-circuit transmission line for each unit is of 45,000-kv.a. capacity, using steel-cored aluminum cable. The connections of 605,000-cir. mil. cable from bushings to the transmission line are carried on suspension-type insulators, from the tower structure on the roof to special towers on the edge of the roadway at the top of the cliff in front of the screen house, thence to a tower structure on the roof of the screen house, from which the circuits spread out to the standard transmission terminal towers. Two circuits connect to existing transmission lines at Niagara Falls, and additional new circuits under construction extend westwards to connect to more distant existing stations on the 110-kv. system.

Emergency Repairs

Shutdowns Prevented by Temporary Arrangements. By H. A. Jahnke

WHEN an accident occurs or something goes wrong with apparatus under our charge, it sometimes seems as if it will be necessary to shut down the entire plant until repairs are made; frequently, however, we get out of the difficulty either permanently or temporarily until repairs can be made. Some time ago a case of this kind occurred where one of the two hot water tanks sprung a bad leak, and no amount of tightening up on the tank bands would stop the leak. It was impossible to empty the tank at the time to find the cause, as this would stop production in the plant.

The tank leaking did not cause any shortage of water for the plant, but the trouble was that the tanks are located in a room above the boiler room and the water was running on top of the boiler, which not only was injurious to the boiler but was also ruining the boiler covering, which is of asbestos.

Placing a piece of sheet iron under the tank at the point where it leaked, then forming one end of the sheet iron so as to drain the water in a 2-in. pipe which was run from the boiler room floor up to the tank room, gave temporary relief. The end of the pipe in the tank room was equipped with a large funnel into which the water from the sheet iron under the tank was drained. The end of the pipe in the boiler room was run into a catch basin, the arrangement being shown in Fig. 1. In this way, no water ran on top of the boiler, and repairs to the tank were made at the first opportunity.

Of course, this was a waste of hot water; but if the plant had been shut down to make repairs to the tank immediately, it would have caused the men throughout the plant to be idle for a number of hours, which would have been more expense than the waste of hot water.

Hot Water Pipe Rusted Through

In another instance, a 2-in. hot water pipe leading from a hot water tank to the boiler feed pump sprung a leak. A hole about the size of a large nail had rusted through it. The pipe was located near the engine room ceiling and the water was running onto the engine and other apparatus. It was impossible to shut the water out of the pipe, as this would mean a shut-down of the plant.

As a temporary repair a pipe hanger clamp was used. First a piece of sheet packing was placed over the hole, then a heavy piece of sheet iron was bent so it would fit over the pipe and sheet packing, then the pipe hanger clamp was placed over the sheet iron and drawn up tight. This stopped the leak until there was time to replace the rusted nipple with a new one. The idea is shown in Fig 2. Iron wedges were placed under the clamp and next to the pipe as the clamp was a little larger for the size of pipe, and these wedges allowed the clamp to be drawn up tight so as to force the sheet packing tight over the hole.

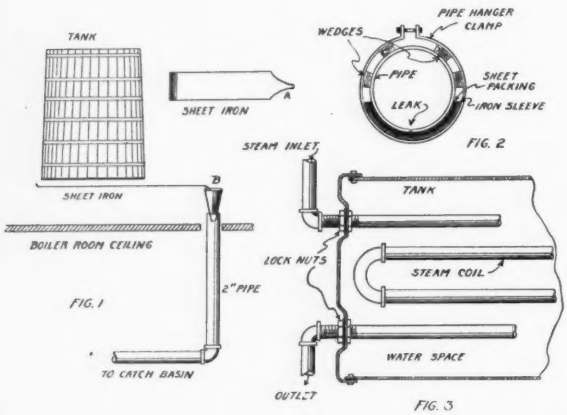


FIG. 1. Arrangement of sheet iron and piping to catch leaking water

FIG. 2. Pipe hanger clamps used to stop leak

FIG. 3. Position of locknut which gave trouble

It was only necessary to shut the water off on the line for a short time so as to place the clamp, etc., as all was made ready beforehand.

Removing Lock Nuts Quickly

A small steel closed tank used for heating water for manufacturing purposes by exhaust steam from the engine has coils arranged as shown in Fig. 3. These coils are held in place by two lock nuts, one on each side of the tank head; back of the locknut on the outside of the head there is a washer, back of which there is packing which is held in place by the locknut and washer. One day this joint started to leak badly. In trying to draw up on the locknut so as to compress the packing more and stop the leak, I found that I could not turn the nut either one way or the other. Pounding as well as heating it with a blow torch did no good. The nut would not move, due to the fact that it was rusted in badly.

Then, to make a quick job, the inlet pipe and elbow from the coil were disconnected, then the old locknut was broken with a chisel and hammer and a new locknut remedied the trouble as well as the leak. Of course, new packing was placed between the washer and tank head before the locknut was drawn up tight.

This experience shows that we waste much time as well as cause expense at times to save some old pipe fitting. Had I broken the locknut as soon as I noticed that it would not move either way regardless of all the pounding and heating that was done, I would have saved much time and labor.

A Gringo in Greaser Land Out of Work

By John Pierce

WELL, fellows, the sad and awful truth must be told—poor old Uncle John started out looking for a job—he had heard from friends up in the "States" that there was nothing to do up there, and some of them had told him that he was foolish to turn loose any sort of a job, and go hunting for something else at this particular time, but of course the old man thought that he knew more than any one else, and so cut loose. And, believe me, fellows, if ever a captain of his ship cut loose and put to sea in a stormy time, and without sails, rudder or even a anchor, why that same captain knows about what sort of thing old Uncle John bumped into. Jobs! Why there ain't no such danged animal. There may have been away back in the olden times when most of us old cusses were still boys, and a lot of us as yet undreamed of, but not lately, son—not lately.

Of course a gringo feels that it is up to him down here in greaserland to uphold the dignity of the great American people, and to show the greaser just what we are, financially as well as otherwise, and you will therefore never find a gringo riding second class, and but very few that will ride first class—NO SIR, not any, "nothing but the Pullman for me."

Well, old John, the poor old fool, he had the same sort of high falutin ideas, and when the chief grafter of the station where he was to embark asked him what class he simply swelled up like most of us do down here and said, "PULLMAN, of course."

The Pullman is a little easier on the springs than the ordinary first class coach, but she sure don't fit good in a poor man's pocketbook, but we took her, you bet you, and we rode her.

Rode her to Laredo, Texas, even if she did eat into the savings so much that the missis had to take off her shoe and dig up a little more from the bottom of her old sock.

Just as we were all settled on the last change, which, by the way, is only half a mile across the international bridge, and which costs $2.70 to travel over, plus $1 for each trunk, and 50 cents for each handbag or valise, extra, the ticket agent came running into the train and said someone had checked his baggage from Torreon and the agent there had failed to collect the excess bag-

gage for it, and as the amount was $11.50 "dobe" money it must be collected before the train could proceed.

Ye gods and green apples—here we sat, able to spit across the line to God's country, and held up because a grafting agent had not as yet got the graft he figured was due him for his morning's effort.

Of course everybody denied having come from Torreon, and what did the sonofagun do but pick on old Uncle John simply because I could talk better to him than the others, and I take my oath I would have sold all my remaining baggage, and almost thrown in all my finances, too, for that much money, and in truth I had NOT come from Torreon—but that didn't matter—there was only one thing to do, and that was to pay it, so I said I'd be eternally damned if I would pay it all—but I did—thereby showing how frail and uncertain the human resolve for it would have cost me more to get out of their jail than to pay, so I paid.

Everything being now fixed we were hauled out onto the international bridge, and left sitting there in the sun until the inspectors on the American side had eaten a melon or two, gone to lunch, and finished their siesta, after which we drew into the American end of the bridge, pulled off our coats, showed our vaccination marks, told how come we had no teeth, proved that we had no money, and lied about our age.

Then we were permitted to pull our trunks out into that nice cool Texas sun and open them up while the curious all had a look to see how much dirty laundry we carried—first a Mexican pawed through it, though he wore an American inspector's badge, then a German looked it over and pulled things apart in order to estimate how well we were able to dress—next an old woman wanted to know if the shoes we had, which had Sears Roebuck stamped on them, were Mexican leather goods or not—then another Mexican had to go through them again to see if we had anything that he wanted or needed in his business, and then they passed us back into the train, told us to wait, talk not to the conductor, and fear no danger.

The peculiar thing about it was that they don't seem to like Americans well enough in this country to employ them as custom guards, inspectors, etc. It may be, of course, that there are not enough of us to do the work.

After two hours more—mind you we went onto the bridge at 9 a. m. and were pulled into the American depot at 4 in the afternoon—having been sitting out there in that breezeless sun all that time, though there was not more than work enough for one man for 2 hr.

Well—the next thing was to get the madam a place to stay—not a place to live, mind you—just a place to stay, for by now I knew it was going to be impossible to eat very long unless Providence was exceedingly kind to us—so we hunted a flat in which was one room, with a bed and a chair, and we moved in—it only costs $35 a month, and you kill your own bedbugs and roaches, a specially appointed hunter costing extra.

Next day Uncle John, clad in his best smile, started out to get the wherewithal to buy the madam a meal.

Naturally he beat it for the Light Company—walked in, asked for the manager, and upon being brought to him said: "Ahem, did it ever occur to you, sir, that you needed a first class engineer or master mechanic in your business?"

Well, he sized me up, walked all around me, looked me over as if I was a choice animal that he was willing to pay a high price for, all the time my heart was bounding up and down, satisfied that I had fell right into something rich, visions of a cute little "scoot-a-bout" Ford dancing before my eyes, when he finally got back in front of me again and said, "Yes, it has so occurred to me, sir; in fact, it occurred to me some time ago that I needed just such a man as you described—and so I got me one—GOOD DAY, sir."

Say—did you ever have that happen to you?

Did I beg him for a job wheeling ashes? No—when I came to I found myself so far away that it was too far to walk back for a job doing that, and besides I wanted to find out what I was talking to myself about when I woke up. Yes, he had got him one.

We never should worry when we stumble, though, for they say that "a worm is the only thing that can't fall down," so I decided to hunt the ice factory next, and sell my valuable services to that company, but I was very careful not to put myself in the same position again, and sweetly rolled my large, long, round eyes at the fair maid in the office and asked for the head of the business—she sent me out into the tank room, and locating him I asked for a job; I told him I was an engineer and well versed in making ice, only to be told that he employed all Mexicans, and they only cost him a small sum per each, but that if I were willing to do my own firing, and work for ONE DOLLAR AND FIFTY CENTS A DAY, the same as the Mexican engineer was getting, I could have the job, but I kindly thanked him, told him I never believed in cutting in under a man already on the job, and so could not accept the place, and besides I never did think any man should draw down more money than he could spend, and I'd hate to be untrue to my long established principles and take so much money each day when it would be impossible to get rid of it—and left him to meditate on my generosity.

I decided that I had done enough for one day and wended my thoughtful way homeward, thinking that tomorrow would be another day, and I'd try again.

The next day was so awful infernal hot, though, that I made up my mind I'd better go over the line and see about taking on a schooner load of good cold beer—which I did—and after hearing from the fellows I met on the other side I decided that there was nothing to hunt further for in Laredo, so I bid the madam a farewell and started to the city of San Antonio, only to find that all the idle men in the world are in that place—they come there from all parts of the country, apparently, and once there they seem to lose all hopes of ever finding anything, and so stay there till they are willing to compete with the greaser in prices, or get run out.

I stayed there several days, and decided that I could not afford any more of that, and started south once more.

Reaching the border I found an unusual number of locomotive engineers gathered around in the little old border town, and learned that a transportation company had got a new concession from the Mexican government, and was in need of engine drivers that could speak Spanish.

It may be well to explain here that in Mexico a peculiar system of railroading is in vogue—the Mexican government gave, some years ago, the concessions to build railroads in that country, especially specifying that it, the government, had the right to purchase 51 per cent of the stock.

Accordingly it took over that amount of stock but, as yet, has never paid a dollar on the principal, nor yet on the interest, though it has shared in every dividend ever paid on the stock.

There has always existed the ruling that any man or firm able to purchase, beg or steal one or more locomotives, could run over the rails, working under the railroad rulings the same as the regular railroad train, and, money being scarce in that country, many of the large companies availed themselves of this rule, and run their own trains.

Then, during the revolutions there, the rolling stock and motive power was so badly torn up that the present government was granting concessions right and left to any one that wanted to bring engines into Mexico and haul cars.

So there was formed a new company that purchased 30 old engines from the American railroads and took them over there, and also bought 12 new ones, intending to put them in the same service, and they were looking for American drivers for these engines.

Well—I needed a job, so I went down to the office and asked for one. They asked me if I was a locomotive engineer and I told them that I was not the best in the world, but that I would run their engines as far over the road as any other American engineer, for I was positive that the Mexican union would not permit it to be done, so I knew I could do as well as any other.

Then they sent a Mexican to me and had him talk Spanish, all of which I answered satisfactorily, and I got me a job, and was told to report for orders the next day.

The locomotives were housed on the Mexican side, and under the charge of the Mexican roundhouse foreman—they were to have had a Mexican fireman, but when we reported for duty and were sent over to take out the train we found also a Mexican engineer at the throttle, and we were told by the master mechanic that we went along simply as "supercargo," all of which was just what I had imagined would happen, and which I told the managers would happen—thus each train left its terminal with two engineers aboard, one of them drawing a salary for being a passenger—I was not doing a great deal of worrying, for it meant less work for the old man, and $425 Uncle Sam's money per month for doing nothing was O. K. with me.

Of the 30 men employed as "engineers" eight of us got out and made our first run—I was very lucky, knowing nearly all the Mexican railroaders, having done more or less repair work on their engines while master mechanic of the other shops, and speaking their language somewhat better than the average, and so got over my own run, and then returning part way helped a couple of the other fellows in—you see we left Laredo, from the Mexican side and made our runs clear into Mexico City, stopping at each division point to rest up, and have our engines examined, for in Mexico on reaching a division point the engineer has to turn in his engine at the roundhouse where the chief boiler maker looks her over and steals anything from her that you can do without, and then the roundhouse foreman gets a shot at her, while following him comes the master mechanic, then the chief electrician, and finally the inspector, then in order to proceed with your train, you are required to make and deliver the following order, keeping one copy for yourself which is signed by each of the chiefs receiving the order, with the hour of signing. We will suppose that we are at Saltillo, state of Coahuillo, and want to move our train south to San Luis Potosi, state of San Luis Potosi.

"Peticion para mover tren, extra, numero 456 al sur.
seis de Julyo de 1920.

Saltillo, Coahuilla,
Senores:

A. S. Gonzales—Jefe de estacion.
D. E. Robles—Jefe de patio.
W. E. Ramires—Jefe de trenes.
U. B. Encinas—Maestro Mecanico.
O. G. Trevino—Jefe de telegrafistas.
Ciudad.

Suplicales correr maquina M. K. T. 456 al sur hasta San Luis Potosi con los carros siguientes.

Juan Torres, maquinista.
Julian Garcia, conductor."

Translated, she says:

"Petition for moving train, extra number 456 south, and is addressed to the chief of 'the station,' chief of 'the yard,' chief of 'the trains,' the 'master mechanic' and the chief of 'telegraphers,' and says 'we pray you to run engine M. K. T. No. 456 south to San Luis Potosi with the following cars ———" (giving car numbers and initials) and signed by the engineer and conductor.

Then all one has to do is to set down and wait till each of these men finish playing his little game of cards, or whatever else is eating on him at the time, and he, in turn, has wired the chief dispatcher that his department is ready to let her go, and then we move on—when the dispatcher has finally got rested enough to issue a clearance—so tell me, you fellows in the States, what business did a poor old fellow like me have trying to break into the railroad game, as complicated as she is?

As I said, we only lasted one trip, and some of us never got started, but as I had made a pretty good showing on my trip they decided that they would put one of us at each terminal point, the Mexican union gracefully permitting this, and call us "terminal superintendents" and let us see to the operation of their trains in this manner, for the unions would not let us go as engineers, and threatened to wreck every train carrying one of us.

I was stationed at one of their terminals and told to get busy—and did so—but after 24 days the union decided that the terminal superintendents must be "train despatchers" and as none of us were that why we had to move on. Why train despatchers is a puzzle, for we had nothing to do with despatching, but these were the rulings of the union, and must be obeyed, though the real and only idea was to get the "gringo" away from the roads, and out of a job, if possible.

So your Uncle John was on the "road" again, but with a little money this time, for he had let the "American dignity" go to hell and had hung onto his earnings,

and he was now in possession, also, of a pass over the Mexican lines, and could travel cheaper.

However, the visions of my little "scoot-about" Ford had all gone by now, and do the best I could I could not imagine hard enough to call up the dreams again, not even the prospect of a Mexican burro would come to make pleasant my thoughts, realizing that something had to be "did" to fool the "wolf" I begun to think of that "Mecca" of all unemployed in Mexico—Tampico—and while the idea hurt, yet it seemed the only thing to do.

I went back to the border and consulted the madam, and she said, "Well, I ain't goin' to support you, so you better git you a job of some sort, and besides if you don't why I know a guy what has a job"—well, that of course decided it—to hold the affections that had been mine for more than 40 yr. it was up to me to make good, to show that I was a success, a "still going strong" old war horse, and I sadly packed my turkey and headed for Tampico.

I got to the place at night, and of course I had to have a place to lay my weary head, and so hunted me a *cheap* hotel and asked for a bed.

They gave me a cot out in a long hall, and I lay down among some two hundred other hogs, and tried to forget my cares in sleep, but the mosquitoes, bedbugs and other things would not agree, so I lay and cussed all night.

Some time in the night some drunk come along and lay down beside me, and as the poor old cot was never intended for such treatment she gently collapsed—but we let her lay and kept right on cussing.

Next morning I asked the charges on my sleeping quarters and learned that it was only three American dollars—great horned toads—how long could I sleep with only a few beans aboard?

A job must be had—there was no question about that part of it—so we starts out—only to find that the oil wells are all shut down, 70,000 Mexicans and 10,000 Americans thrown out of work, not a thing to do, the Mexicans getting ugly, fighting going on all about the place between the unemployed men of the two nations, revolutions in the making, more reductions in men ordered, more wells to be stopped, and two warships of Uncle Sam nosing up the river, while the trains were loaded down with Gringoes going out—and old John about broke and a stranger in a strange land—yea, verily, my lines had fallen in hard places—but I was bound to satisfy myself that there was, or was not, a job for me, and went to every place in the town and near the town where men were employed but was told at every place that it was useless to stay there and waste my money, for the place was to be closed completely down—one firm that is well known all over the world and that uses Diesel engines looked over my papers, and sent for the very chief of the works, and he was kind enough to tell me that of all the men in the camp he would be best pleased to keep me on account of my ability to handle his Diesels and to make me his master mechanic, but that he had received orders from the head office to let *every one* go and to shut down tight.

By this time I had been in town several days, and the coin was fast going, so I figured that I would give it one more try and go myself.

All that day I found no encouragement, and that evening as I was wending my sad way townward I chanced to pass along the wharves and found an ensign from the "Sacramento" with a number of sailors waiting the ship's launch and we fell to talking.

About this time the launch came driving up the river with the American flag in its becket, and made for the dock, upon which a great mob of peons and mechanics seized the flag, tramped on it, and threw it into the river, all the time calling the sailors all the filthy names in their vocabulary, and which the sailors were powerless to answer as one word would have brought on the war we were all expecting.

While roaming about the town during these few days I had seen much fighting against the Americans, and many indignities heaped on them, and after seeing what had been done to the flag and knowing that these Mexicans thought we were afraid of them, and knowing that they were wanting to start something I decided that it was no place for a minister's son and came home.

Meantime I had received letters from my old stamping grounds that had been forwarded me and which contained letters from all over Mexico from friends who were out of work, and all told the same story, "no work, no hopes of any, what can you offer?" And there were also letters from good men from various parts of the States saying that they were out of work here, and wanted me to find them something to do in Mexico.

And—I leave it to ye editor of "Power Plant Engineering"—I am not a loafer, but as yet there has been not a thing for old John to do, though he has gone all over this southern country hunting a job at any kind of thing.

The wife had a job, though, and the old boy still ate, though it nearly choked him to eat the provender of the woman—but don't get the idea into your heads that the old man was down and out, for "I had just begun to fight."

ACCORDING TO a recent report from the U. S. Geological Survey, the average daily production of electricity in kilowatt-hours by electric public utility plants in March was less than that for February by a little more than 1 per cent. The average monthly output for each of the past 5 mo. is as follows: November, 121,300,000; December, 123,200,000; January, 123,200,000; February, 123,800,000; and March, 122,500,000. These figures show that there has been little change in the average daily production of electricity by public utility plants since November, 1921, and indicate that the normal seasonal decrease in output during the late winter and early spring months is apparently being replaced by an increase in the demand for electricity.

HYDROELECTRIC development is proceeding rapidly in Italy, the state of Lombardy having 121,934 hp. under way in addition to the 326,309 hp. now in operation: Piedmont has 109,386 hp. in construction and 365,530 hp. in operation; Umbria is developing 30,136 hp. and is operating 168,363 hp. Total hydroelectric stations now operating in Italy deliver 1,191,797 hp., which is 60 per cent of the amount for which development rights are authorized. The power now in operation for the three most developed power states is for Umbria, 24.55 hp. per 100 inhabitants, for Piedmont 10.68 hp. and for Lombardy 6.82 hp. per 100 population.

Governor Troubles

SOME TIME ago, the governor on a high-speed engine suddenly developed a peculiar noise while running. This governor is a Rites inertia as shown in Fig. 1. The noise was a cross between a whistle and a squeak. All joints and bearings, except one are equipped with compression grease cups and the other one is oiled with a can before starting engine. At the first opportunity

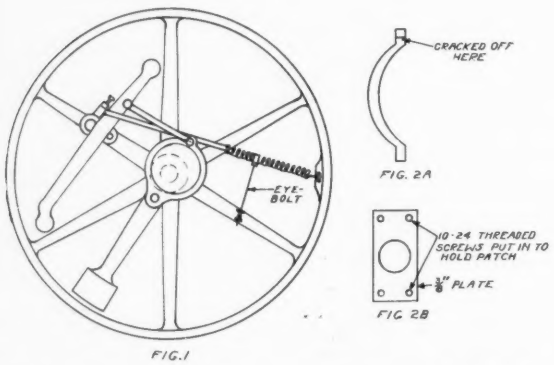


FIG. 1. LOCATION OF EYE BOLT THAT CAUSED GOVERNOR TO SQUEAK

FIG. 2. BROKEN ECCENTRIC STRAP AND REPAIR

the whole governor was gone over and all holes where grease cups were attached were cleaned out, but noise was still there.

The governor was gone over again to see if there were any parts loose. The trouble was finally located in the eye bolt. This is attached to a collar around the spring and goes through a spud set in a spoke. The purpose of this bolt and collar is to steady the spring to keep it from vibrating. The bolt was screwed up towards the spring too far, throwing it out of line. After adjusting the eye bolt to the proper length the squeak was gone.

On another engine, 10 hp., with the same make of governor but having only a single arm, a loud rattling developed and before the engine could be stopped the eccentric strap broke. The main pin was threaded on the end and passed through a hole in the hub of the flywheel, screwed into the governor arm and was kept from unscrewing by a set screw in the governor arm to lock it with. The set screw worked loose and the arm could rock sideways on the pin as the threads were a loose fit. This rocking caused such a violent rattling that the strap broke, as shown in Fig. 2 at A, and was repaired as shown in Fig. 2 at B. This engine runs a 40-in. fan to supply the blast for the stokers and has to run all the time. The job was done and engine running in 10 min.

Figure 3 illustrates a peculiar accident that caused a 22 by 48-in., 72 r.p.m. Corliss engine to run away. The threaded collar was fastened to the sleeve on the governor spindle with a set screw, which worked loose.

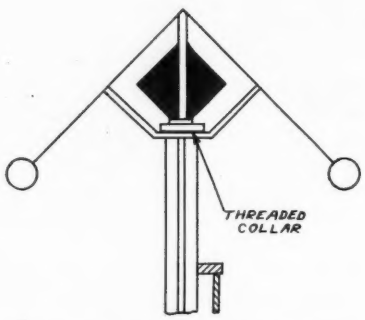


FIG. 3. LOCATION OF THREADED COLLAR WHICH CAUSED RACING OF ENGINE

The sleeve was threaded for quite a bit farther than the thickness of the collar. The direction of rotation of the balls screwed the collar down on the sleeve and the effect was the same as if the governor belt had broken only the safety stop did not work, as it was impossible for it to do so.

The engineer shut the steam off before engine was wrecked, but several high speed wood-working machines were torn loose from their foundations by the excessive speed and vibration. The insurance company compelled the owners to put on an automatic engine stop

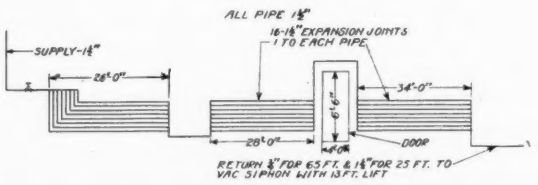


FIG. 4. POOR ARRANGEMENT OF HEATING COILS

and throttle valve that has an automatic trip on the main shaft of the engine and stop stations in the factory from which the engine may be shut off also.

Figure 4 illustrates a "bonehead" heating coil installation. I have read with great interest the articles by H. A. Jahnke on heating systems and the right and wrong way of connecting them, but this beats anything I ever read. The supply line is 1½-in. pipe and is 45 ft. from its source to the branch tee of first coil.

The condensation and steam came out of the bottom of the first coil and into the bottom of the manifold of the second coil. Coil No. 2 discharged out of the top of the outlet manifold and was carried over a door and down into top of manifold on head end of coil No. 3. The return line from this coil was ¾ in. for 65 ft. and then was increased to 1½ in. for 25 ft., from which point it connected into a common return and rose vertically 13 in. Pressure carried on this layout was 35 to 55 lb. Sometimes it worked and again it froze up. Coils Nos. 2 and 3 were made up with Branch T's having all right-hand tappings. To get them together, an expansion joint was put on each pipe.

Recently we had a new smokestack erected at our plant. The stack is of 8-gage steel made up in 10-ft. lengths. The joints on both ends of each length were flanged so that they could be bolted together without a man having to get inside of the stack as was formerly necessary when all joints were riveted up on the job. This is a new thing in this part of the country.

In traveling around the country we often hear about insufficient draft, but in our case if we did not have to comply with a city ordinance requiring a stack 100 ft. high, measuring from the grates, we could run indefinitely without a stack. The stack gang told me that we could run as long as we pleased or could, as it would not be any bother to them. The stack was taken clear down to the base, which stuck 18 in. above the roof. Steel to start raising the new stack was held up

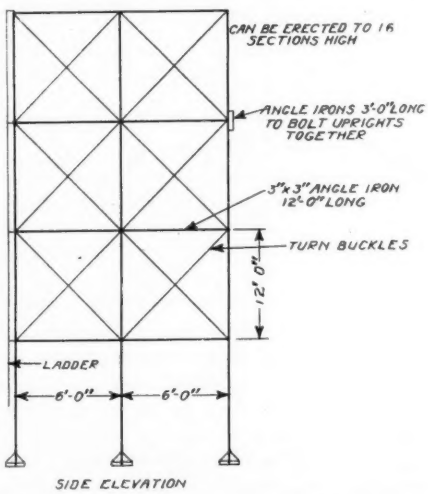


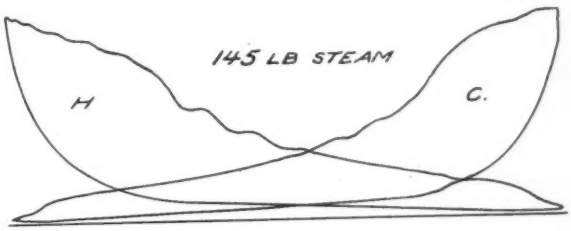
FIG. 5. PORTABLE STEEL STAGING USED IN ERECTING SMOKE STACKS

3 hr. in delivering, but we had no trouble in keeping up steam, but had to open the dampers quite a little more than usual to keep away from a pressure over the fire. This stack is 37½ in. outside diameter and takes care of two 72-in. by 18-ft. boilers. In the erection another new apparatus in this territory was used in the shape of a portable steel staging to be used in taking down and erecting steel stacks. It is made of 3 by 3-in. angle iron in 12-ft. sections and can be used for any height of stack up to 185 ft. It is 12 ft. on the long side and 8 ft. on short side with six sets of uprights as shown in Fig. 5. Turnbuckles are used to hold it from jackknifing, and 3 by 3-in. angle irons 12 ft. 8 in. long are used for cross pieces and plank supports. To join the uprights, pieces of 3 by 3-in. angle iron are used. These are bolted on the end that goes up so that the next one can be set in against it and support its own weight while bolts are being entered. When erected, the stack to be torn down is in one compartment and the other is used for lowering the old sections and hauling up new ones. Three men unloaded and erected it to a height of 100 ft. in 1½ days, took down the old stack and put up the new one in 2½ days and took down and painted the stack in one day. It used to take 3 to 4 days to build up wooden staging with only one compartment and every time they took one down from 1 to half a dozen pieces would drop through the roof. Nothing came through on the steel staging job.

OPERATOR.

Comment on Diagram from Engine at Badger State Tanning Co.

IN DESCRIBING the plant of the Badger State Tanning Co. at Sheboygan, Wis., in our June 1 issue, a series of indicator diagrams were shown which illustrated the equality in work done in each end of the cylinder over



INDICATOR DIAGRAM TAKEN FROM SKINNER UNAFLOW ENGINE UNDER RATED LOAD AT NORMAL THROTTLE PRESSURE

a big range in load. All of these cards were taken at a throttle pressure of about 110 lb. per sq. in., whereas the operating pressure for which the engine was designed was 140 lb. As a result, the full load card, which in reality shows a load about 15 per cent in excess of the rated capacity, shows an exceptionally long cutoff which, without explanation, might lead to the assumption that the engine was over rated. Herewith is shown another card from this engine, taken with a throttle pressure of 140 lb. per sq. in. The load in this case is about 10 per cent below rating.

He Did It While Under Pressure

AN INTERESTING experience was brought to my attention not long ago regarding a young refrigerating engineer who put a safety valve on a receiver single handed and alone while the receiver was under pressure.

This engineer had decided that a certain receiver needed a safety valve. None was on it, the opening being closed with a nipple and a valve on top of the nipple.

He prepared for the job by having an ammonia cylinder shipped to the plant into which to transfer the charge. Upon learning that the cylinder had arrived he went there himself and proceeded to empty the receiver; however, he found that the cylinder was not large enough and that a considerable quantity of ammonia still remained in the receiver.

Not wishing to undo the work he had already done and delay the matter further by waiting for another ammonia cylinder, he decided to put on the valve against the pressure.

He prepared for the task by arranging a fan to blow the fumes away as well as possible. He warned all occupants of the building and advised them to get out for a minute or so, which was possible in this instance as it was in a meat market. Then he donned his gas mask and went to his work.

Upon unscrewing the nipple and valve the pressure threw them up against the ceiling. Quickly picking up the safety valve which he had already arranged in the most convenient place and position, he found that he could not press it down against the ¾-in. pipe opening with his hands alone, but that the weight of his body was necessary in addition. So, with his chest lying against the top of the valve and with his two hands he forced the valve against the opening and after a few twists got the threads to catch. After that it was easy of course.

While pressing the valve in place, considerable ammonia blew against his body. He says it felt warm to him, due partially, he thinks, to the fact that he was perspiring freely and that the perspiration absorbed considerable ammonia. During the absorption process as is well known, heat is generated by the chemical reaction. He does not know whether it was this heat that he felt or whether the extreme cold felt like heat in the same way that liquid air feels hot to the touch.

N. G. Near.

Pipe Fitting Notes

There are many small points about power plant work which the beginner learns, you might say, only by accident. For instance, the novice may be sent to the store for a 2 by 2 by 1½-in. pipe tee. He brings the tee given him, but seldom indeed does he ask why the storekeeper did not give him a tee with one of the ends 1½ instead of the center. The reason is, of course, that in asking for a tee the ends are named first, the center last.

One day an amusing incident occurred. A helper was sent for a one-inch tee, the center to be left threaded. He was warned to make sure it was the proper opening left threaded. Shortly afterwards he was sent for a one-inch right and left elbow; he returned without the elbow, saying he had forgotten to ask which end was wanted left threaded.

A beginner in power plant work should be warned against the common practice of using bushings instead of reducing fittings; they make an expensive and unsightly job; as their use increases the number of threads they thus increase the possibility of leaks. On small permanent pipe work, say from 1 to 2 in., I prefer to use right and left couplings instead of unions if their use will not cause undue strain on the pipe line. Their cost is about ⅓ that of unions and, when properly installed, make a permanently tight connection. A good grade ground faced union could be used on small pipe work which might have to be taken apart frequently.

All defective pipe fittings should be hammered flat if of malleable cast; ordinary cast-iron fittings found defective should be broken, which prevents their being accidentally installed as good fittings.

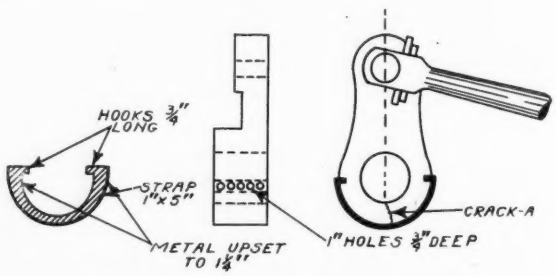
The practice of throwing defective fittings into the same compartment as that containing the good ones has resulted in much loss in valuable time and labor by workers using them as good fittings. When the old time steamfitter found a defective pipe fitting, he would give it a coat of red lead on the outside; other pipe fitters, seeing the lead, knew at once that the fitting was no good.

James E. Noble.

Repairs to Engine Crank

While I was employed in a sugar refinery in Brooklyn, N. Y., some years ago, a rather unusual breakdown occurred on an 18 by 36-in. blower engine, of the Corliss type. A crack (A) was discovered in the crank, extending from the shaft to the outer edge of the crank, on the face, and from the shaft, halfway to the edge, on the back, presumably due to some imperfection in the forging. Although the crank was still tight on the shaft, it was deemed unsafe to operate the engine in that condition. It was estimated that it would take at least two weeks to obtain a new crank from the factory, and install it on the engine, and the service could ill be spared for even one day shift.

A repair was made, which proved so satisfactory that during the two years I was there, no steps were ever taken to install a new crank. A 1-in. slot, ¾ in. deep,

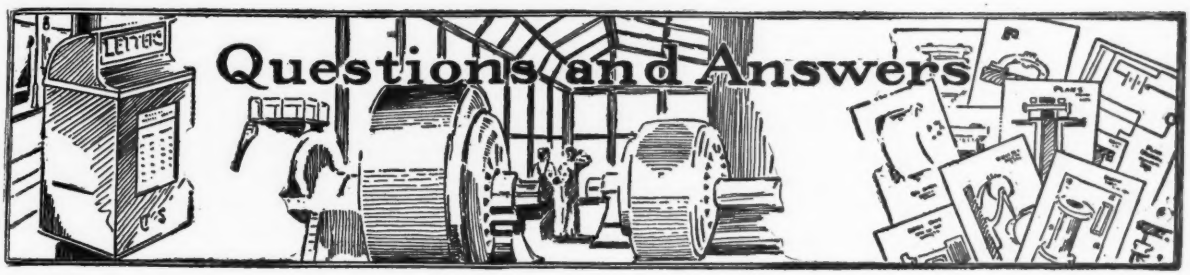


DETAILS OF REPAIR TO ENGINE CRANK

was cut on each side of the crank, opposite the shaft center, by drilling a row of holes and chiseling out the cores. A portable drill-press was rigged up, and driven from a convenient shaft-pulley, and the engine put on centers, to bring the work on top. A strap of 1 by 5-in. steel, with hooks turned on the ends, the strap being upset to 1¼ in. at the throat of the hooks for extra strength, was fitted around the crank, as shown in sketch, then upset to ½ in. shorter than the distance between the slots. The strap was heated in the center, and hammered around the crank, care being taken to have the hooks properly entered in the slots. The strap was then cooled with water, drawing the metal together and closing the crack. The engine was put in service in the morning, the work having been accomplished by two machinists, a blacksmith, and a helper, in 11 hr. (night-work) without disconnecting the engine.

M. M. Brown.

Wisconsin Minnesota Power Co. contemplates building a $2,000,000 hydroelectric plant at Jim's Falls, north of Eau Claire, Wisc. The plant is to be 4000 ft. from the river necessitating the building of a canal. B. S. Hilliard, the engineer in charge, is located at Eau Claire, Wisc.



Trap Installation

WE HAVE an installation of a steam receiver and trap which has been the subject of considerable discussion and I would appreciate your opinion of it.

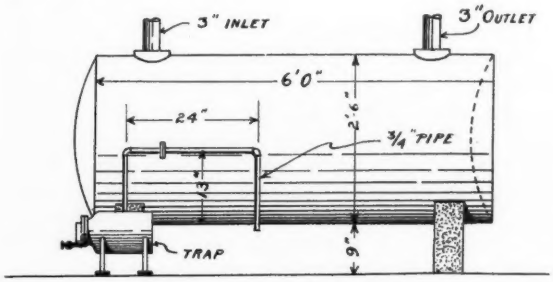
There is a drum type receiver connected to the main steam supply line to one of our departments, the function of which is to separate the water from the steam before it reaches the apparatus. This receiver is 30-in. in diameter by 6 ft. long, installed horizontally on the floor. Into opposite ends, at the top of receiver, are connected the 3-in. steam inlet and outlet. The steam pressure is 125 lb., ordinarily, but 160 lb. is carried at times.

Connected to the center of the receiver, at the bottom, is a steam trap. This trap is float controlled, but has a tripping mechanism which causes it to open wide open or close off completely.

The ¾-in. pipe connection from bottom of receiver to inlet of trap is brought out horizontally from the bottom of receiver to the front side, then rises vertically 13 in. then horizontally 24 in. and is connected to inlet of trap which is set on the floor. The discharge from the trap is connected to the sewer.

Will the trap, as installed, keep the receiver free from water or will the water in receiver rise 13 in. (the height necessary to fill connecting pipe to trap) before the trap will operate?

What effect will condenser action of trap have on its operation?



RECEIVER AND TRAP INSTALLED

Is this installation considered good engineering?

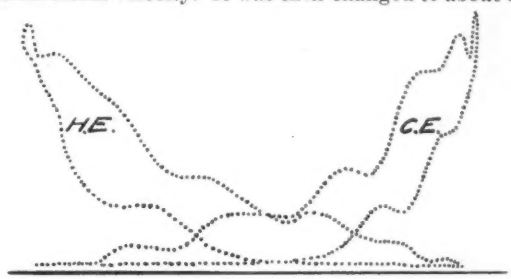
Is it ever proper to set a steam trap above coils it serves?

A. G. H.

What Is the Cause of the Wavy Lines?

THE TWO accompanying indicator diagrams were taken from a 15 by 18-in. single cylinder, piston valve, steam engine, ooperating non-condensing, with an average steam pressure of 94 lb. gage (saturated) and an average speed of 265 r.p.m. The load consisted of two fans belted to the engine and operating at light load.

The first card was taken with the indicator pipes about 12 in. above the cylinder, on the assumption that the length of pipe was such as to produce close to the critical steam velocity. It was then changed to about 3 in.



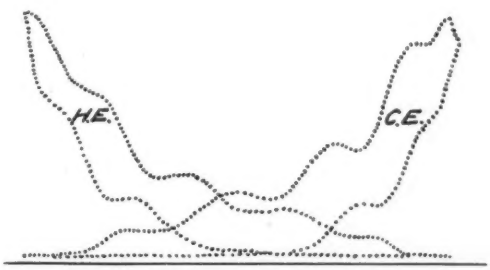


FIG. 1. CARD TAKEN WITH LONG INDICATOR CONNECTIONS
FIG. 2. CARD TAKEN WITH SHORTENED PIPING

above the cylinder. Card No. 2 shows the same wavy characteristics as with the long pipe.

The engine is old and in poor condition, but we have been unable to account satisfactorily for these peculiar cards. Attention is also directed to the pencil chatter.

We would appreciate an analysis of these cards.

B. L. S.

Salary and Commission for Engineers

ONE OF our readers, who is chief engineer and master mechanic in a small industrial plant, contemplates making a few changes in his equipment with the idea of effecting greater economies in operation. He would like to have a share of what he is able to save his company and would like, therefore, suggestions as to how be can arrange to work on a salary and commission basis. How shall he figure his savings and to what portion of these savings should he be entitled?

The plant consists of 150 hp. of installed boiler capacity, one 35-hp. steam engine, one 35-T. steam driven ice machine, and two 8-T. motor driven compressors. Current for these motors is purchased from an outside source.

Suggestions, as to how this system of compensation

is carried out, from engineers who have been employed on that basis or who know where it has been used, would be appreciated.

What Causes These Peculiarities?

THE ACCOMPANYING indicator diagram (Fig. 1) was obtained from a 30 by 36-in. York ice machine engine running at 44 r.p.m. under a steam pressure of 140 lb.

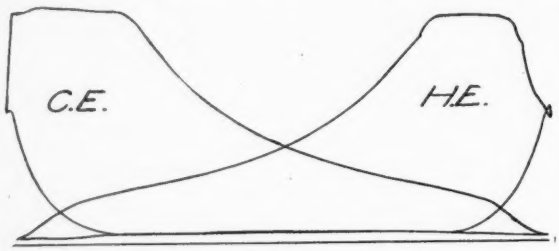


FIG. 1. INDICATOR CARD FROM AN AMMONIA COMPRESSOR ENGINE

What is your opinion as to the cause of the hook on the head end and what remedy would you suggest?

D. M. B.

THE CARD shown in Fig. 2 was taken from a 14 by 32-in. Corliss type engine running at 130 r.p.m. with

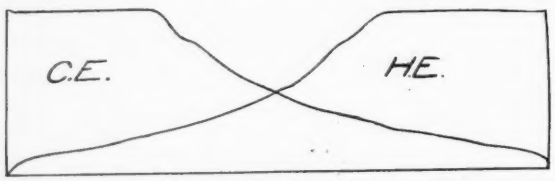


FIG. 2. CORLISS ENGINE INDICATOR CARD SHOWING LACK OF COMPRESSION

150 lb. steam pressure. What would cause the lack of compression indicated on the diagram? I. J. E.

Design of Small Transformer

WILL YOU kindly give me data and directions for constructing an air cooled ½-kw. transformer for transforming 60-cycle, single-phase current from 110 to 220 v.? E. P.

A. The design of transformers such as this one is more or less subject to rule of thumb methods as it is not known just how far equations used in the design of large power transformers are applicable for this class of work. It is possible to supply data for the construction of this piece of apparatus, but it is not possible to predict accurately what the performance will be. Manufacturers of small transformers have of course worked out empirical designs but such data is not available to outsiders.

The procedure employed is to assume the efficiency and then work backward. To deliver 500 w. at 220 v. will require a current in the secondary of $500 \div 220 = 2.27$ amp. Assuming an overall efficiency of 90 per cent, the primary current will be $500 \div 110 \div 90 = 5.05$ amp. The loss amounts to 10 per cent of 500 w. = 50 w. which for our purpose may be considered to be equally divided between copper and core losses.

With a flux density of 55,000 lines per sq. in. in the core (a value which has been found to give good results) the losses will amount to about 0.376 w. per cu. in. of core. As the total core loss is 25 w. the volume of the core is found to be $25 \div 0.376 = 66.5$ cu. in.

To arrive at a determination of the shape and size of the core, we assumed various combinations of dimensions and found that a core having a mean magnetic length of 25 in. can be used. This gives a section of 2.56 sq. in. (1.6 in. square).

The number of turns on the primary may be determined from the equation

$$N_1 = (10^8 \times E_1) \div (4.44 \times f \times b \times a)$$

where E_1 is the primary voltage; f, the frequency; b, the flux density, and a, the area of the core section. Substituting the known factors in this equation, we find

$$N_1 = (100{,}000{,}000 \times 110) \div (4.44 \times 60 \times 55{,}000 \times 2.56) = 283$$

The length of the mean turn may be taken as equal to 0.3 of the length of the mean magnetic circuit, i. e., $0.3 \times 25 = 7.5$ in. The total length of wire necessary for the primary is then

$$283 \times 7.5 \div 12 = 177 \text{ ft.}$$

The total copper loss, which was taken as 25 w., can be assumed to be equally divided between the primary and secondary coils, in which case the loss in the primary would be 12.5 w., that is, the I^2R loss = 12.5 w. As I is 5.05 amp., $I^2 = 25.5$ and the resistance is then

$$R = w \div I^2 = 12.5 \div 25.5 = 0.5 \text{ ohm}$$

approximately. If this resistance is found in a length of 177 ft. the resistance per foot of the primary winding will be $0.5 \div 177 = 0.002{,}825$ ohm.

By referring to a wire table, it is found that the size wire having this resistance is No. 14 B. & S. gage.

The number of turns on the secondary, N_2, will be $283 \times 2 = 566$. The secondary current is 2.27 amp. and I^2 is therefore 5.15. The resistance of the secondary is then

$$R_2 = w \div I^2 = 12.5 \div 5.15 = 2.43 \text{ ohm.}$$

The length of the wire in the secondary is $566 \times 7.5 \div 12 = 354$ ft. and the resistance in ohms per ft will be $2.43 \div 354 = 0.006{,}87$.

Referring again to the wire table, we find that No. 18 gage wire should be used.

The core, as has been said, has a mean magnetic length of 25 in. and a section 1.6 in. square. Using No. 28 gage stock (0.0156 in.) for the laminations we will require about 100 layers to make up the total depth. There will be needed then 200 end pieces, 1.6 by 4.8 in., and 200 side pieces 1.6 by 8 in. Half of the side pieces are piled together so that every other lamination overlaps 1.6 in. This bundle is then taped and the coil wound on it. The other side piece and coil is prepared in the same way, then the end pieces, which have been built up in a similar manner, are dovetailed into the sides and the whole is clamped together.

How Should High Pressure Flanges Be Drawn Up?

IN THE June 1 number of Power Plant Engineering O. L. W. asks the above question.

A number of things can be the matter. It is the writer's opinion that O. L. W. is not to blame at all, but that the trouble can be charged against the manufacturers either of the gaskets or the flanges.

It is not uncommon that the engine and pump builder makes the mistake of not giving enough attention to the proper strength and enough bolts for flange connections.

In the first place, a plant should be built under careful supervision with proper and standard equipment throughout—gaskets, as well as anything else. The flanges should be of the correct size and should be properly drilled. They should be heavy enough to withstand the taking up of the bolts. Also the bolts should be sufficient in number and of the right diameter and strength. It may be that the present bolts are so weak that they stretch just a little bit after each tightening. It is quite possible that the elastic limit of the bolt material has been passed.

Also one can look to the gaskets themselves as being inadequate for the duty. What is the pressure? Are they subject to vibration, expansion, and contraction? If so, are they flexible enough to take care of the vibration and expansion?

If the gasket is the right kind and if the other conditions are at least normal, it will hold without any retightening. W. F. SCHAPHORST.

Weir Capacity

WE ARE at present installing two vertical centrifugal pumps, each having a capacity of 1000 gal, per min. In order to test these pumps I have decided to build a weir. This weir must be large enough to accommodate the discharge from both pumps at the same time as we will be compelled to run the two pumps at certain times of the year. Will you kindly give me some information as to the size of weir required, the dimensions of notch, and the method of figuring the flow?

J. K.

A. To arrive at the correct size of weir to be used to measure the output from your two 1000 gal. per min. pumps, we make use of Francis' formula:

$$Q = \frac{2}{3} \times 0.622\ h\ (b - \frac{1}{10} nh)\ \sqrt{2gh}$$

where Q is the flow in cu. ft. per sec., b is the width of notch in feet, h is the depth of water over the sill measured back from the plane of the sill where the velocity of approach is practically zero, and n is a coefficient whose value depends upon the form of the weir. If the area of approach is large as compared with the product of b times r, or in other words, if there is perfect and complete contraction, n = 2. Where there is contraction on one side of the notch only, n = 1, and where there is no contraction on either side, then n = 0.

Assuming complete and perfect contraction, n = 2. If we assume also that b = 2 h, which is a proportion frequently found, we find

$$Q = \frac{2}{3} \times 0.622\ h\ (2h - 2h \div 10)\ \sqrt{2gh}$$

or $Q = 6\ h^{2.5}$ approximately.

If Q = 2000 gal. per min., or 4.46 cu. ft. per sec.

$h^{2.5} = 4.46 \div 6 = 0.745$

or $2.5 \log h = \log 0.745$

hence $\log h = (24.872 - 25) \div 2.5 = 9.949 - 10$

and h = 0.89 ft.

As b = 2h we find b = 1.78 ft. Thus we can say that a weir 12 in. high by 2 ft. wide would be ample to handle your maximum flow.

In determining the flow from observation of conditions at the weir, this equation is solved for Q; h and b having been carefully measured. A greater degree of accuracy will be required for this computation than was used here in order to secure satisfactory results.

Discharge Through Short Pipe

A QUESTION that arises often in actual power plant practice is, how much water will a certain size line discharge under a given pressure? For example, what will a 3 in. line discharge into a tank when under 30 lb. gage pressure at the pump? The pump is located only a few feet from the point of discharge. All I am after is a rough estimate based upon theory, of course. All of the formulas that I know take into account friction loss and other factors which, it would seem to me, could be forgotten when an error in the result of 10 or 15 per cent is of no consequence. H. M. T.

A. The discharge through the pipe you mention may readily be figured as discharge through a short pipe. The quantity discharged in cubic feet per second is equal to the area of the pipe times the velocity of flow. The velocity can be figured as equal to $\sqrt{2}$ gh, or $\sqrt{2\ g \times 2.3 \times p}$, where "p" is the pressure in pounds per square inch. This is the velocity of the water entering the pipe, but at this point the net section is reduced, due to contraction on entering the pipe, to about 60 per cent of the actual area and the flow is less than it would otherwise be. "Q," the quantity of flow, equals then $0.6 \times 0.7854\ d^2 \times 12.2\ \sqrt{p}$, cu. ft. per sec., when multiplied by 7.5, the number of gallons in a cubic foot, we have the answer in gallons per second. This reduces to $Q = 43\ d^2 \times \sqrt{p}$ gal. per sec. If "p" is 30 lb. per eq. in., $Q = 43\ d^2 \times \sqrt{30} = 236\ d^2$ gal. per sec.

The only coefficient used in this case is that due to the contraction of area at the entrance, which, as you will note, is rather large. By omitting it an error of about 40 per cent would be made. The error due to neglecting friction in the pipe is small here and may well be neglected.

Oil or Electricity?

THE PLANT in which I am employed consists of one 125- and one 100-hp. horizontal return tubular boiler which furnish steam for a 12 by 24 in. Corliss engine driving a 30 kw. generator; two deep well pumps, about 60 gal. per min. each; and a 40-T. ammonia absorption refrigerating system. Besides this there is a 7½-T. motor driven ammonia compressor.

We contemplate electrifiying this plant so we are going to take out the two boilers now in service and substitute one of 60 hp. capacity for the creamery. We will also take out the absorption machine and put in a motor driven compressor of slightly larger capacity. To operate these motors we will either purchase our current or put in an oil engine-generator set.

Would the oil engine proposition be better than buying power at 2½ c. per kw.-hr. or would the reverse be true?

THE HIGHEST form of salesmanship is nothing but service.—Forbes Magazine.

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Checks on Plant Performance

Regardless of a man's intention to turn in an accurate record of the performance of his power plant, there are so many factors which enter into the summarized report that it is a wonder reports come within several per cent of being accurate.

Instruments used in power plants as aids to operators are not in the precision class. Comparatively few plants are provided with a sufficient number of instruments to determine the quantities desired in a report so that the engineer resorts to calculations using assumptions which at best are only approximately correct. Frequently weights of materials are calculated from dimensions with assumed values of specific gravity. Often the arrangement of instruments permits unavoidable inaccuracies to creep into the readings which give false impressions and, of course, errors in calculations will appear occasionally as one of the frailties of mankind.

Fortunately in the realm of science men have devised means of proving or checking the correctness of calculations or even, in many cases, the readings of instruments obtained during a test. It is difficult indeed to doctor up the results of a test so that an expert in working up test data collected from a number of instruments cannot detect inaccuracies which would affect the final result seriously.

Likewise in the everyday operation of a power plant the record of readings taken from one instrument should bear a quite definite relation to those from other instruments and if that relation does not exist something is wrong with the data and an investigation is in order.

One of the slogans which has appeared on these pages for some time is to keep and analyze power plant records, and under the process of analyzing would come the checking of the readings for accuracy. Mr. Henderson now comes to the aid of those who are consistently using their records to obtain highest economy by suggesting in this issue how the heat balance may be used to check the coal and water weights given in a boiler room report. While this check method is not new to the test engineer it is not commonly used in the daily operation of power plants where readings are taken, many times, by men who do not appreciate their value in keeping the plant up to the top notch. Striking off a heat balance for the boiler plant should be considered as important as the monthly balance of the bookkeeper.

Turbine Generating Unit Performance

Those of our readers who have been following the progress in the development of large turbo-generators should be interested in the article on "Turbine Generating Unit Performance" which appears in this issue. We have all been interested, more or less, in noting the steady increase in the capacity of turbo-generators which has characterized turbine construction during the past decade and have wondered at times where the race for large capacity was going to stop.

From a thermo-dynamic view point the building of large-sized turbo-generators was fully justified, for each increase in size was usually accompanied by an additional increment in thermodynamic efficiency. There is, however, another point besides efficiency to be considered in turbo-generator construction, and that is reliability of operation. Efficiency may be a governing factor

affecting design, yet the true measure by which the success or failure of any machine is determined is in its operating performance.

In order to determine with a fair degree of accuracy just how reliable modern turbine units are, a study has been made of the operating performance of 78 large units installed in 27 of the largest power stations in the country. These performance records shown in the pages of this issue, furnish a fair basis from which to determine the degree of reliability that may be expected from modern turbines. The black marks on the charts represent the time that the turbine was down for repairs during periods when there was a demand for its service.

A glance at these charts is sufficient to inform us that much work remains to be accomplished before we can expect 100 per cent reliability. There are, obviously, too many black spots upon the charts. These must be eliminated. While we do not wish in any way to underrate the excellent work accomplished by the Prime Movers Committee in collecting this data, we wish to point out that the investigation should be extended.

The next thing that should be determined is the exact cause of the outages shown on the charts. What was the nature of the trouble which forced the machines to shut down? If this can be ascertained, the manufacturers will have something of real value with which to work in their endeavor to produce machines of greater reliability. It is to be hoped that during the coming year, the Prime Movers Committee will continue the excellent work which they have started and that in the next report they will present specific information regarding the cause of the outages.

Off Duty

"Transmutation of elements achieved."

Thus, in massive headlines, did the daily newspapers recently proclaim to some six millions of readers the results of a series of experiments conducted by two investigators at the University of Chicago. To say the least, these headlines were extremely interesting. Unfortunately, however, the newspaper reports were for the most part based upon an exaggerated Associated Press dispatch and although the scientific world was not seriously disturbed over them, the general public probably received erroneous impressions.

Transmutation of elements! Ever since medieval times when the alchemist spent a lifetime in a vain effort to change base metals into gold, this phrase has always possessed a singular charm to anyone with even the slightest degree of imagination. And it was only the rapid development in chemistry and physics during the middle '80s that finally served to dispel the dreams of the transmutationists. After that it was a display of gross ignorance to even mention transmutation—a social blunder as it were. Transmutation was taboo.

Developments in radioactivity in recent years, however, have somewhat altered our views and today we are not so positive that the dream of the alchemist was so futile as we have been inclined to regard it. And, for the past few years, that renowned exponent of radioactivity, Sir Ernest Rutherford, has been amusing himself by knocking electrons from nitrogen atoms, and by this action, changing them into hydrogen atoms. Indeed, we have been half inclined to kick ourselves for laughing at the poor old alchemist. He may have been on the right track after all; he didn't know it, however.

Power Plant Slogans

Keep and Analyze Operating Records in Every Power Plant.

Develop Water Power Sites.

Promote Health and Safety in Power Plants.

Handle Coal and Ashes Mechanically.

Employ Engineers for Engineering Work.

The recent experiments of Irion and Wendt, to which the newspapers had reference, consisted in sending a powerful condenser discharge at 100,000 v. through a very fine tungsten wire. The filament exploded with a deafening report producing a flash estimated to correspond to a temperature of at least 50,000 deg. F. After the discharge the tungsten wire had totally disappeared and the vacuum tube in which it was contained was found to contain helium gas. Apparently the discharge had caused the disintegration of tungsten into helium.

While this may appear to be a definite proof of transmutation to the layman, it is by no means proof to the scientific world. As Sir Ernest Rutherford points out in commenting on the newspaper reports, "while the appearance of helium gas has often been observed in electrical discharge tubes it has generally been assumed that this helium was in some way occluded in the associated material."

Another point that needs further investigation is the disposition or measurement of the energy produced by the atomic decomposition. From our knowledge of radioactivity and modern atomic theories, we are led to expect the liberation of large amounts of energy with the breaking up of one atom into another so the actual measurement of energy liberated in these experiments would be a far more definite and delicate test of disintegration of the heavy elements into helium than the mere presence of helium gas itself. "This," as Mr. Wendt puts it, "is one of the rare examples of the preference for theory over fact."

While Mr. Wendt's and his associates' work has not progressed far enough to permit the measurement of energy evolved, it is certainly not as large as would be expected from the energy liberated in the disintegration of radium.

The lack of theoretical data, on the other hand, does not explain the formation of a cubic centimeter of gas from half a milligram of tungsten. It may be as Mr. Wendt points out in an article in Science, that the atoms of the more stable metals contain less energy than the unstable radioactive elements, from which our knowledge of interatomic energy has been obtained. Indeed, even among the radioactive elements the violence of disintegration varies inversely with the stability.

So as to whether actual transmutation has been accomplished still remains a question, the results of the experiments seem to indicate that we are traveling in the right direction. Much work still remains to be done; but given the backing and equipment they need, we may place unbounded faith in the patience and the ability of those brilliant investigators who are constantly blazing the trail on the frontiers of science.

A. I. E. E. Convention

INTERESTING PAPERS ON DIVERSIFIED SUBJECTS, LIVELY DISCUSSIONS AND LARGE ATTENDANCE WERE OUTSTANDING FEATURES OF MEETING AT NIAGARA FALLS, ONT.

TO SELECT a more appropriate place and one which would draw a larger attendance than Niagara Falls, Ont., for the Thirty-eighth Annual Convention of the American Institute of Electrical Engineers, held June 26 to 30, would indeed be difficult. Not only were the physical surroundings attractive, but the program covered the electrical engineering field well and the social features were well interspersed to break up monotony.

During the sessions of the convention, 955 registered and although the papers dealt for the most part with special problems, there was a sufficient variety to make it a profitable meeting as well as a pleasant outing to all who attended.

Section delegates held their meeting dealing strictly with Institute affairs on Monday, but the Convention did not assemble for discussion of papers until Tuesday morning when President McClellan introduced A. Monroe Grier, president of the Canadian Niagara Power Co., who gave the address of welcome. There were also addresses by President McClellan, A. P. M. Fleming, manager of the research and educational department of the Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester, England, and President-Elect Frank Jewett.

Following the general session, the convention divided into two sessions for the reading and discussion of the papers.

"The Two-Stage Current Transformer" was the title of a paper presented by H. B. Brooks, of the Bureau of Standards, and F. C. Holtz, of the Sangamo Electric Co., in which the authors presented a brief discussion of the current transformer as used with measuring and controlling apparatus with special reference to the degree of accuracy which can be attained in the ratio and phase angle. A new type of current transformer was described, with which, the authors assert, it is possible to secure much higher accuracy with a given amount of iron and copper in the transformer.

In this new device, the transformation is effected in two stages, the first yielding in the usual way a secondary current which is approximately correct in magnitude and phase, and the second yielding an auxiliary corrective current which, combined with the first secondary current, gives a resultant current which very closely approximates the secondary current which would be furnished by an ideal current transformer having no errors. The two currents may easily be combined by having two like windings in the devices operated, one for the main and one for the second auxiliary current.

That ratio or phase angle effects introduce no serious errors with certain designs of current transformers of the ordinary type was the contention of J. R. Craighead, who showed slides and gave data to prove his statements in the discussion of the paper.

J. L. R. Hayden and W. N. Eddy, both of the General Electric Co., presented a paper giving the results of 3000 tests on the dielectric strength of oil. These were made in six groups with 500 tests in each group under constant conditions of test. Three groups of tests were taken of standard insulating oil with three different shapes of the electrostatic field; small sphere gap, large sphere gap, and sphere-needle gap. One group of tests was made with commercial and another with chemically pure benzol. The last group was made with air as a dielectric. In contrast to air, the behavior of oil is very erratic. This inconstancy of the disruptive strength of oil appears inherent to the material. Much of the variation is due probably to the complex chemical and physical nature of the oil.

Benzol gives far more consistent values of disruptive strength than oil, the more so the purer it is; nevertheless, benzol is much more erratic than air.

Under successive tests oil, first slowly and then more rapidly, deteriorates by carbonization due to the disruption. Benzol deteriorates very rapidly at first, and then becomes very constant. Filtration restores the initial disruptive strength, but the filtered material seems to deteriorate more rapidly than new material. This information indicates that there is either an intermediate chemical state of the disintegrated product or an absorption.

Barriers were suggested by O. D. Wood as a means of preventing irregularities in breakdown limits. That moisture is the principal impurity in oil was generally conceded, but Dr. Steinmetz cited tests that tend to prove that moisture does not cause the variability of breakdown limits.

The paper entitled "Control of Gaseous Conduction," by V. Bush and C. G. Smith, of the American Radio and Research Corporation, called attention to the fact that in electric circuits of all sorts, power is transmitted principally by metallic conductors. In order to control the flow of power, or to convert it from one form to another, the constants of the circuits are varied. The connections of the metallic conductors may be altered for this purpose; but on high potentials, this operation is attended with difficulty. The rapidity and ease of control are also limited.

For this reason there has been a tendency, in recent years, toward the increased use of control devices employing non-metallic conduction. Devices employing conduction by gaseous ions have been handicapped in this general evolution by three main disabilities, the first being the difficulty of placing the discharge where wanted, the second, the tendency of the working gas to disappear, and the third, decidedly erratic action. These disabilities, it is claimed, have recently been to a large extent removed by the advent of a principle called the "short path principle," by which discharge can be prevented except where wanted.

By utilizing this principle, gaseous conduction devices may be designed, for example, as rectifiers. The present models, as described, are capable of handling only small amounts of power; but there is no inherent limitation in this direction. The usual conditions of cost, reliability, life and so on will determine development for higher powers.

In the paper "Determination of Temperature of Electrical Apparatus and Cables in Service," E. J. Rutan of the New York Edison Co. emphasized the importance of temperature measurements in the work of the test department of an electric light and power company in the acceptance and maintenance of the electrical equipment. Four methods of measuring temperature which are applicable to this work were discussed in this paper. These are by thermometers, by resistance thermometers, by thermocouples and by change in resistance in the winding or circuits of the apparatus under test. The characteristics of the different kinds of temperature measuring apparatus are brought out by describing a number of actual tests.

In the article considerable attention was given to various forms of thermocouples which have been found very useful in obtaining temperature measurements on cables and in underground conduit systems. The discussion of this paper brought out the practice of others in measuring temperatures of service apparatus.

"The Economics of Direct Current Railway Distribution" with particular reference to the automatic substation by Lawrence P. Crecelius and Victor B. Phillips, both of Crecelius and Phillips, Consulting Engineers, Cleveland, O., called attention to the comparatively recent development of the full automatic substation and also the automatic substation combined with remote control, which has served to re-open the entire subject of the economics of distribution. But quite aside from the questions that the automatic substation has presented, the great fluctuations in the prices of materials and of labor have made necessary renewed study of this subject. In other words the proper design of a distribution system should represent a balance between all of the different items of cost that go to make up the total cost of power.

Any change in the relative cost of materials as against labor or of a certain class of materials as against another class of materials tends to upset such a balance. Now that we begin to emerge from the unsettled conditions of the past few years during which the old relationships have been substantially changed, it is necessary to ask the question whether or not the rules by which distribution systems have been planned in the past still apply.

It was the purpose of this paper to determine, first, the relations that govern the size of feeders and the correct feeder layouts for any given arrangement of substations, and, second, the principles underlying the correct location, size and type of substations, assuming the fullest development of automatic and semi-automatic control.

In the discussion, electric railways were urged by D. W. Roper to bring their distribution systems up to date by the installation of automatic substations and closely located substations.

Small automatic substations were favored by W. E. Bryan, in preference to large ones; but he warned against drawing general conclusions and expecting them to apply to specific cases. M. J. Lowenberg declared that one must "not use Kelvin's law to throw the burden on the stockholder," but stated that the controlling factor should be the permissible voltage drop.

Ward Harrison of the National Lamp Works, in his paper "Light Without Glare," showed that brightness of the source, total flux of light directed toward the eye and contrast in brightness between the light source and its background are factors which must be controlled in order to produce satisfactory illumination without glare. The relative importance of these factors was discussed. The paper included tables from the Illuminating Engineering Society Code of Industrial Lighting in which for the first time various light sources, both natural and artificial, are classified from the standpoint of glare. The use of these tables was explained and illustrative examples are given.

S. E. Doane thought that engineers should spend time in educating the public in better lighting, that electric companies are not selling merely electric energy but light, heat and power in the applied form.

The paper by James J. Pilliod, of the American Telephone and Telegraph Co., dealing with the Philadelphia-Pittsburgh section of the New York-Chicago cable, took up the engineering and construction features involved in a complete telephone cable system over 300 mi. in length connecting Philadelphia and Pittsburgh, Pa.

A method of determining resultant input from individual duty cycles and of determining temperature rating was described in the paper by Bassett Jones, consulting engineer. Before it is possible to put a group of motors into service, it is necessary to provide means for generating and transmitting the energy which probably will be required to operate them. To select the proper and economical capacity of such generating and transmitting equipment requires that some reasonably correct estimate be made of the probable amount and probable time distribution of the combined load due to the motors when in service. This paper presents for the first time, it is believed, an application of the theory of probabilities to the starting and stopping of motors.

Tuesday afternoon was given over entirely to the presentation and discussion of four papers on the Queenston-Chippawa development, the titles and authors of which are as follows:

Queenston-Chippawa Development of the Hydro-Electric Power Commission of Ontario, by F. A. Gaby, Chief Engineer, Hydro-Electric Power Commission of Ontario. Description of the 45,000 kv.a. Queenston Generators, by B. L. Barnes and F. Bowness, both of Canadian General Electric Co., Ltd. Design of 45,000 kv.a. Generators, Queenston Plant, by R. A. McCarty, Engineering Department, Westinghouse Elec. & Mfg. Co., and H. U. Hart, General Manager, Canadian Westinghouse Co. Features of Main Power House Transformers for Queenston Plant, by C. A. Price, Assistant Chief Engineer, Canadian Westinghouse, and M. E. Skinner, Assistant to General Manager, Duquesne Light Co.

These have been combined and abstracted and appear on other pages of this issue.

President McClellan took just a few moments Tuesday evening, when the informal reception and dance was held, to point out some of the objects of the Institute.

Rating of Equipment Based on Temperature Rise

Considerable difference of opinion has existed among manufacturers and users of electric generators

as to the proper method of rating these machines based on temperature rise and the entire session with the exception of one paper on Wednesday morning was given to a consideration of this subject.

Of these papers F. D. Newbury of the Westinghouse Electric & Manufacturing Co. presented two, these being entitled "Questions Relating to Standards of Rating with Particular Reference to Large Machines Using Class B Insulation," and "Probable Values of Conventional Allowance for A-C Generator Stator Windings." In these papers Mr. Newbury discussed the principle employed in the A. I. E. E. Standards for determining the limiting temperature rises as a basis for rating calling attention to the lack of agreement in the so-called hot-spot principle and advocating the establishment of a standard based on the observable temperature rise itself without the consideration of intermediate steps and proposed that the standard for turbo-generator stator coils be placed at a rise of 90 deg. C., measured by imbedded detectors, above the surrounding atmosphere. The electric machinery sub-committee was not able to agree on this value but recommended 80 deg. C. as a safe standard to which there seemed to be hearty agreement. In his second paper he presented the results of specific tests on a large armature which had for their object the determining of the value of the conventional allowance for the particular method of measurement which he advocated when applied to a given class of alternating current machine stator windings for given temperature limits.

Philip Torchio of the New York Edison Co. contributed to the discussions a paper entitled "Temperature Limits in Large Machines." He pointed out that the present Institute standards allow a maximum limit of 105 deg. C. for fibrous insulation and 125 deg. C. for mica insulation with an allowance of 150 deg. C. subject to special guarantees of the manufacturer. In high-voltage machines of large size, the effect of actual copper temperatures higher than 105 deg. may cause softening and disappearance of binding materials, bulging of insulation, and consequent powdering of insulation under periodic pounding of copper on softened material, and ionization at voids so created.

Operating experience with four large size machines demonstrated the above effects to take place repeatedly in machines operating at copper temperatures of 150 deg. C. None of these effects were noted in machines operating at copper temperatures of 105 deg. C. or under. Two machines have safely operated for over 3 yr. at maximum copper temperatures of 130 deg. C. Incorrect conclusions may be made as regards the safe temperature limits by judging the performance of machines unless actual copper temperatures are known. Lower ambient temperatures and fractional loads may reduce the operating temperatures 25 to 35 deg. below the assumed limits.

Other correlated and important features discussed incidentally in the paper were the typical proportionality of life at different temperatures for fibrous insulation, and the new tentative conventional allowance for reducing to maximum copper temperature, readings taken outside the insulation.

Frederick A. Scheffler, of the Fuller Engineering Co., in his paper "Higher Steam Pressures or Pulverized Coal," assumed a hypothetical power or public service steam plant of 100,000 kw. nominal capacity and compared the cost of operation of such a plant on a basis of 250 lb. pressure and 600 deg. F. total steam temperature, and 400 lb. pressure and 700 deg. F. total steam temperature, when fired by stokers and pulverized coal. The results of the comparison indicate that, with much lower capital costs, even better thermal plant efficiency will pertain with the use of pulverized coal and the lower steam pressure than would be the case with the higher steam pressure plant, stoker fired.

Nobody missed the inspection trip to the Queenston hydraulic plant Wednesday afternoon. Though still in the course of construction, two 45,000 kv.a. hydraulic turbine generators are in operation under a head of 305 ft. and when completed this plant will be the largest hydraulic plant in the world.

At the evening session J. L. Harper gave a lecture on the power plants using the waters of the Niagara, carrying his audience in an entertaining way through the local history of the industry, pointing out many mistakes that had been made and how they were overcome, illustrating his lecture with lantern slides showing features of construction and closing with a series of moving pictures of the falls and rapids.

Reviews of the papers read on Thursday and Friday of the convention will be given in the next issue of Power Plant Engineering.

Service as a Business Builder

THE KEYNOTE of modern business is service. Experience has shown that the big business concerns which have persisted through the ups and downs of business cycles and increased continually in strength until they have become what may be called an institution, have counted service among the greatest of their assets.

The first element of service to the buying public is to furnish quality in the product turned out. The second element in service is to maintain contact with the product standing behind it, and assisting the purchaser to get out of it all to which he is entitled.

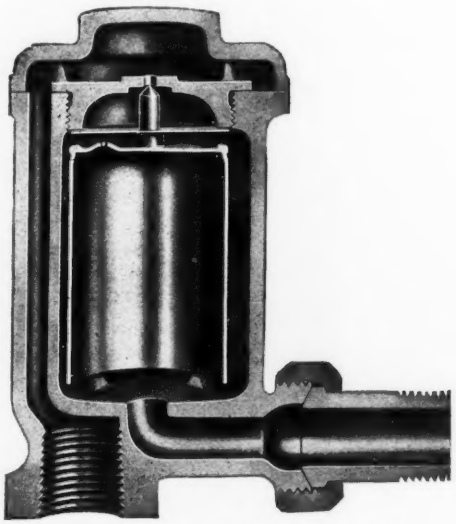
The Heine Boiler Co., of St. Louis, has recently taken steps to systematize still further the method by which Heine boilers in use are followed up. This method consists in arranging the itineraries of field men in such a way that they can conveniently visit and report on a considerable number of Heine installations, a specific report to be made on each installation in accordance with certain desired information.

The purpose of these visits is to establish connection with the boiler users and ascertain what results are being obtained. Advice is given wherever the representative feels qualified to advise, otherwise questions are referred to the engineering department. These field men are provided with suitable blanks which assist them in making out reports which can be filed and conveniently referred to in the main office.

This service in the boiler industry is an especially good example of broad-minded business policy, because a boiler properly installed and maintained will last a lifetime. Therefore, in following the performance of boilers, there is no renewal business that can be obtained. It is done with the sole idea of creating good will, the most permanent foundation for future business.

Armstrong Radiator Trap

THE ARMSTRONG Machine Works has just developed and placed on the market a new radiator trap of the bucket type. It is extremely simple of design and consists of but three parts, the body, the cap, and the bucket, which is the only moving part, as shown in the accompanying illustration. On the inner wall of the body there are three guides machined with enough clearance to insure accurate seating of the valve. The bucket consists of a tube, one end of which is open; the other is closed by a cap which carries the valve stem. The outside cap carries the valve seat. By means of ports in the cap, the discharge from the valve orifice is carried to a port on the side of the body which extends to the bottom outlet connection.



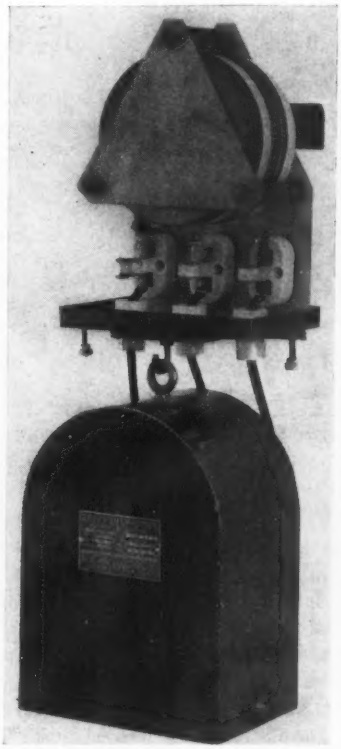
NEW BUCKET TYPE RADIATOR TRAP

When the inverted bucket is full of steam, it acts as a float and closes the valve. When full of water, it acts as a weight pulling the valve off its seat, and thereby allowing the water to escape. Air entering the bucket rises through a vent in the closed end of the bucket and is discharged with the steam. Any steam which may pass this vent is condensed in the water above the bucket.

New Type of Oxide Film Lightning Arrester

THE GENERAL Electric Co. has recently placed on the market a new form of oxide film lightning arrester, especially adapted for the protection of mill power circuits. These arresters, which are designed for use on 300 to 1000 v. alternating current are made for either indoor or outdoor use, as desired, and furnish the same degree of protection for the motors and transformers used in mill power work that the larger arresters do for high voltage power apparatus.

The arresters consist of standard oxide film cells arranged for connection between line and ground through a small gap. The arrester proper is enclosed in a sheet metal housing, the cover of which can be easily removed for inspection or repairs. The arresters are made for three styles of mounting; cross arm, wall, or on a shelf. They require no more inspection than the other kinds of apparatus used in a mill, except the periodical inspections that any arrester needs at the end of the lightning season, and after thunder storms.



NEW FORM OF OXIDE FILM LIGHTNING ARRESTER

The use of these arresters is good insurance against the loss of time and money from shutdowns of the electrical apparatus of a mill due to lightning disturbance.

Water Rights Purchased by Pacific Gas & Electric Co.

CLINTON L. WALKER will receive $40,000 from the Pacific Gas & Electric Co. in compensation for his riparian rights on 160 acres of land along Pit River above the company's pit No. 1 power house.

The company could not start up its great power house at Pit No. 1 until the Walker water right had been condemned and paid for. There is one more water right that must be condemned also before a wheel can be turned. The trial of this case has been set for Sept. 7.

THOSE WHO talk of scientific methods in engineering work are too apt to think that nothing is scientific unless it is the outcome of laboratory research and is properly mixed up with mathematical formulas. . . . A man is just as scientific in his methods if he bases his actions on experience gained in a workshop as is a professor who draws conclusions from what happens in a test tube. The only requirement in each case is that observations shall be exact and the deductions logical.—Engineering of London.

Venting Protection for Renewable Fuses

THE SHURVENT Renewable Fuse recently developed by the Westinghouse Electric & Mfg. Co. is designed to overcome the problem of satisfactory venting in renewable fuses.

The construction of this fuse acts on the principle of baffles because it retards the flow of gas sufficiently to maintain enough pressure within the cartridge to extinguish the arc, and it also allows the gases to leave

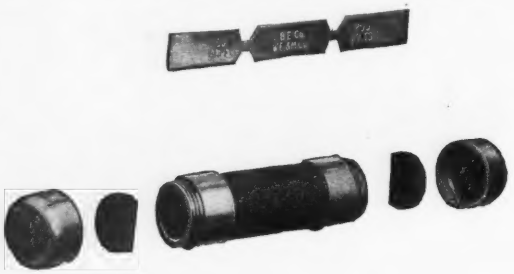


FIG. 1. SHURVENT RENEWABLE FUSE OF FERRULE TYPE

the fuse only after they have been cooled to a temperature that eliminates all hazard of fire, or of personal injury.

In the Shurvent design, the distinctive feature, which meets the ideal fuse requirements, is the positive method of venting and cooling the hot gases generated when the fuse volatilizes. The usual method for emitting these gases is along the threads between the ferrule and the casing. This tends to cause the ferrule to freeze on the casing, and to char the threads of the casing, thus decreasing the life of the original fuse.

Shurvent fuses have a series of fixed washers at each end of the casing. These washers are channeled to form air chambers and they are connected to the inside of

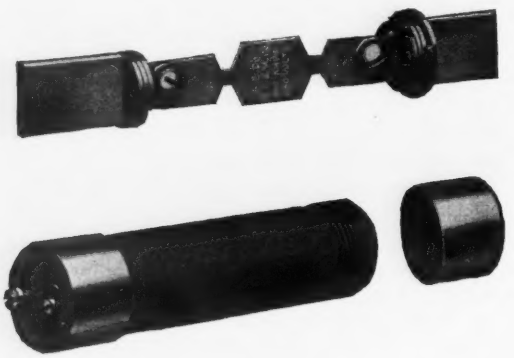


FIG. 2. SHURVENT RENEWABLE FUSE OF THE KNIFE-BLADE TYPE

the casing, to each other, and to the outer air by staggered openings. The hot gases will follow these courses more readily than along the threads, but they will be retarded sufficiently to accomplish two purposes—effective quenching of the arc in the casing, without damage to the casing itself, and cooling of the gases so that they will leave the fuse at a safe temperature.

A specially designed bone fiber tubing assures long life of the casing, and the minimum number of parts assures ease of renewing and obviates the possibility of losing parts that would make the fuse inoperative.

In the knife-blade type, the links are solidly bolted to the copper terminals. This construction assures a contact superior to that in which the use of tools is entirely avoided.

In renewing the ferrule type fuse, the only parts to be removed are a cap and a washer from each end, while

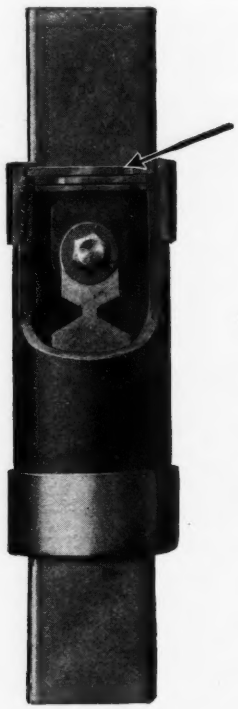


FIG. 3. VIEW OF FUSE SHOWING FUSE LINK, AIR CHAMBER AND PATH FOR VENTING

only one ferrule and the loosening of the screws at the other end are necessary in the renewal of the knife-blade type. These screws are permanently fastened to the end washers so that they cannot be dropped and lost.

G. W. P. Authorized to Expend $3,653,073

PERMISSION to employ approximately $3,653,073 for the purpose of financing a program of extensions, betterments and additions to its present system, was obtained by the Great Western Power Co. of California recently from the State Railroad Commission. The funds, part of which are to be derived from the proceeds of a previously authorized $2,000,000 bond issue and the remainder through the sale of $2,000,000 par value of the company's 7 per cent cumulative preferred stock, will be expended principally as follows:

Purchase of the properties of the Universal Electric and Gas Co., $1,125,000; Golden State substation, $140,003.64 and $388,004.96 for other miscellaneous additions and improvements.

The company reported to the Railroad Commission

in its application that practically all of the bondholders will exchange 8 per cent bonds for Series "B" 7 per cent first and refunding bonds so that only a small part of the proceeds of the $2,000,000 issue will be necessary for redemption purposes.

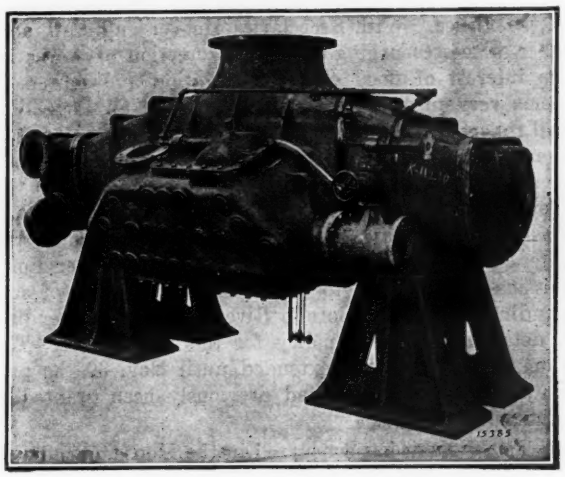
The company's expenditures announced for the current year aggregate $2,383,285, and are allocated to its various districts as follows: San Francisco, $489,050; Oakland, $1,361,485; Sacramento, $179,000; Big Bend, $35,000; San Mateo, $11,500; Rio Vista, $82,000; Northwestern, $40,250; Big Meadows, $185,000.

New Surface Condenser for Springfield Plant of Diamond Match Co.

THE ACCOMPANYING illustration shows a shop view of a small Ingersoll-Rand surface condenser recently installed in the plant of the Diamond Match Co. at Springfield, Mass. This condenser serves a 600-kw. turbine.

This construction, with the separate cooler mounted on the shell, is a characteristic of this type of surface condensers. In this cooler, the air and non-condensable gases are devaporized before being finally drawn off by the vacuum pump equipment.

Air is withdrawn by a steam jet vacuum pump in combination with a small secondary reciprocating pump.



SMALL INGERSOLL-RAND SURFACE CONDENSER

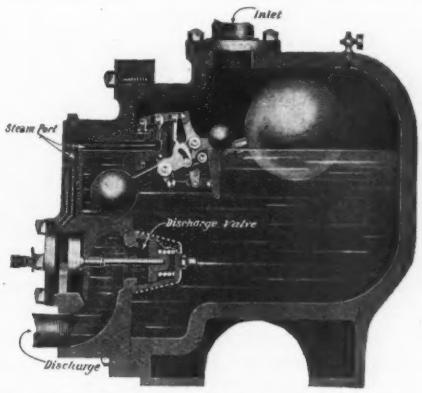
The primary steam jet is mounted on the cooler dome and the secondary jet on the tee shown. The secondary vacuum pump takes its suction from the open end of the tee.

Condensate and circulating water pumps are Cameron centrifugal motor driven units.

Piston Operated Steam Trap

THE steam trap recently brought out by W. H. Nicholson & Co. is unique in that the discharge valve is operated by a piston, actuated by steam pressure. The discharge valve, as may be seen in the accompanying illustration, is direct connected to a steam piston which is instantaneous in its action.

As water accumulates in the trap, it raises the float which, at a predetermined point, trips a counter weight, which, in falling, opens a pilot valve, admitting steam behind the main piston, which opens the main discharge



SECTION OF WYOMING PISTON OPERATED STEAM TRAP

valve. As the water is discharged the float falls and closes the steam valve. The steam behind the piston condenses and allows the discharge valve to close, which action takes place before the water level has fallen to the level of the discharge opening, thus maintaining a water seal.

Income of P. G. & E. Shows Increase in 1922

DURING the first five months of the current year the total net income of the Pacific Gas & Electric Co. amounted to $4,992,130, an increase of $488,975 over the corresponding period in 1921, according to income statement of the power utility made public recently.

The gross revenue of the power utility for the period included in the fiscal report amounted to $16,223,520, an increase of $281,117. Operating expenses, taxes and depreciation totaled $11,301,390, representing a decrease of $207,858. Interest and amortization of bond discount and accrued dividends on preferred and common stock, totaled $862,292, and this figure was $226,717 in excess of the balance for the same period in the previous year.

At the close of the period under discussion in the 5 mo. income statement, the company's plants and properties account, exclusive of current assets, stood at $190,751,000, an increase since May 31, 1921, of $18,-170,000, the income statement discloses; and the latter sum represents the amount of new capital invested in the business of the corporation within the period of one year, it is stated.

Proposed Consolidation of Power Plants in Washington

CONSOLIDATION of light, heat and power services of the City Post Office and Government Printing Office with the existing Capitol power plant as proposed, say Public Printer Carter and Architect Woods of the Capitol, will thereby effect a great saving. The third deficiency appropriation bill, if approved by Congress, will attain this economy through appropriat-

ing $271,000 to equip the Capitol plant for the whole work, thus avoiding the separate bills of $140,000 and $157,000 for rehabilitation of the independent plants. It is pointed out that the consolidation into one plant means smaller appropriations for power plant payrolls, fuel and water, and increases efficiency by making space for other purposes in the overcrowded printing office and post office. Economies resultant from the pooling of resources are: The saving of 1,200,000 gal. of water daily, costing the District of Columbia water works about $40,000 annually. The reduction in employes' wages by the suggested change would be another saving of $6000 a year. The existing smoke nuisance would be eliminated through the intended switchover. A uniform load of the Capitol plant thereby will be effected, resulting in savings on cost per kilowatt hour of current consumed. The mechanical payroll in the printery boiler room plant will fall from more than $300 daily to less than $150. Annual haulage of 14,000 T. of coal, and the resultant ashes on which $50 removal charges monthly are paid, is done away with by consolidation, as the Capitol hill plant has its own railway siding.

News Notes

DATES FOR the Thirteenth Annual Convention and Exhibition of the National Association of Practical Refrigerating Engineers have just been announced. This convention will be held on Nov. 1, 2, 3 and 4, 1922, at the Planters Hotel, in St. Louis, where the entire second floor of that hotel, which is one of the largest in St. Louis, has been engaged for exhibition and meeting purposes.

A. B. MCDANIEL of Washington, D. C., has been appointed chairman of a committee of the American Association of Engineers to make an analysis of government engineering positions with the purpose of determining just what qualifications are required. The committee is assured of the co-operation of Dr. C. R. Mann and of government departments employing large numbers of engineers.

MOUNTAIN STATES POWER Co. has arranged to purchase 12,000 kw. from the California-Oregon Power Co. to be delivered over a 115-mi. transmission at 110,000 v. to the substation at Springfield, Oregon. The line will be of size 00 bare copper wire on suspension type insulators, 350-ft. spans and will take power from the plant on the Rogue River at Prospect.

E. B. PHILLIPS, of Jacksonville, Fla., has been appointed instructor in electrical engineering at Carnegie Institute of Technology, Pittsburgh. He will join the staff of the College of Engineering on Sept. 1. Mr. Phillips is a graduate of Georgia Institute of Technology, class of 1917, and for the two years following was an electrical engineer with the Western Electric Co. in New York City. During the past two years Mr. Phillips has been instructor in electrical engineering at the United States Naval Academy, Annapolis, and at Georgia Tech.

Another important change in the Department of Electrical Engineering at Carnegie Tech next year will be the retirement of Prof. A. J. Wurtz from the staff of the department. Beginning next fall, he will devote all of his time to research work in electrical engineering for the Division of Co-operative Research continuing research work he has been doing on a part time basis in the College of Engineering. The acquisition of Prof. Wurtz to the Research Division is of particular interest to electrical engineering companies, because of his contributions to the development of electrical engineering. He is the discoverer of the five non-arcing metals, and has made many notable inventions during his career.

EXTENSION OF the plant of the Chambersburg Electric Light Co. at Chambersburg, Pa., has been necessitated through the increased demand for electric power. The equipment, consisting of a 1000-kw. turbine generator unit, for the proposed extension has been ordered by the city of Chambersburg from the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. The projected extension is being made under the direction of A. C. Wood, of Philadelphia, consulting engineer.

THE CHICAGO section of the Association of Iron & Steel Electrical Engineers recently elected the following officers for the season of 1922-23: Chairman, Charles Donovan, American Sheet & Tin Plate Co., tin mills, Gary, Ind.; Vice-Chairman, Henry E. Davis, Interstate Iron & Steel Co., 118th St. and Calumet River, South Chicago; Committeeman, R. L. McIntosh, Inland Steel Co., Indiana Harbor, Ind.; and Committeeman, Gordon Fox, Freyn, Brassert & Co., 122 S. Michigan Ave., Chicago.

THE RECESS which has been taken by the House of Representatives interrupted hearings on the Swing Bill providing for improvements on the Colorado River. The hearings will be resumed immediately on the reassembling of the House. With Secretaries Hoover and Fall, and other witnesses urging immediate erection of works in the interest of flood control, irrigation and power, it seems very probable that the Committee on Irrigation will report the bill favorably. The discussion before the Committee indicates that there will be important amendments, however, before the measure is reported to the House. The mining interests in the lower Colorado Basin are becoming insistent upon some action in the interest of a power supply. The Federal Power Commission has declined to depart from its policy of suspending action on Colorado River applications pending a determination of a policy for the entire river. The Commission, however, extended until Nov. 30 the preliminary permit which had previously been granted to James B. Girrand.

THE SENATE has concurred in the House amendment to the Army Bill delaying until October 1, next, all new work on the Wilson Dam at Muscle Shoals. This was the cause of discussion in the Senate condemning this further delay to the project.

A. B. NEUMANN, who as chief engineer for the United States Steel Corporation designed and built the Gary plant, and who for the past 3 yr. has been chief consulting engineer for the Steel and Tube Co. of America, has opened offices as consulting engineer in the Peoples Gas building, 122 South Michigan Ave., Chicago.

A NUMBER of changes have been made recently in the personnel of the Power Sales Department of the Westinghouse Electric Co., East Pittsburgh, Pa. The changes include the promotions of three managers and the creation of two new managerships in the Power Department and are effective immediately.

L. C. Bullington, who has been assistant to the manager of the Power Department for the past several years,

has been made assistant manager and will have charge of the general work of the Power Department. Charles F. Lloyd, formerly manager of the Substation Section, has been made manager of the Electric Division and P. E. Carothers, formerly manager of the Turbine Section, has been appointed manager of the Steam Division.

The vacancies caused by the promotions of Mr. Lloyd and Mr. Carothers have been filled by the elevation of Bruce H. Lytle and D. O. Tylee, the former becoming manager of the Substation Section and the latter manager of the Turbine Section.

M. H. AYLESWORTH, executive manager of the National Electric Light Association, stopping off in Denver, said that Colorado leads all Western states in the use of electricity on the farm and in the home, and within a few years will lead the country along electrical lines. Denver, he said, is known throughout the country as "The City of Lights," and will compare electrically with any city of its size.

Mr. Aylesworth said that development of the use of electricity in the United States is a good indication of steadily increasing prosperity. More than 1,000,000 homes were wired for electricity in 1921 and more than 2,000,000 farms are already provided with electricity.

THE ECONOMY Fuse & Mfg. Co. of Chicago announces the appointment of Chas. H. Bluske as district sales manager of the Los Angeles office at 1304 Maltman Ave. Mr. Bluske was formerly connected with the Pacific States Electric Company of Los Angeles, and succeeds Geo. L. Davis.

The Pittsburgh sales office of the company has been moved from 2223 Farmers Bank Building to 1006 Peoples Bank Building at Fourth Ave. and Wood St.

THE MCCLAVE-BROOKS CO. announces that its Pittsburgh office, Oliver Building, has been placed in charge of George Blair, Jr., who remains district manager of the Philadelphia office. Mr. Blair has promoted Alfred F. Duemler, former sales engineer of the Philadelphia office, to assistant manager of the Pittsburgh office. W. H. Goodrich, manager of the Syracuse office, recently resigned and H. L. Hergett, now manager of the Pittsburgh office, will succeed him.

WALTER S. GOLL, a graduate of Sibley College, Cornell University in 1896, and since 1897 with the General Electric Co. in the railroad engineering department at Schenectady and in subsidiary companies, has been appointed manager of the Ft. Wayne, Ind., works to succeed Fred S. Hunting, recently resigned.

STANDARD GAS AND ELECTRIC CO. reports continued increase in both gross and net earnings, with most encouraging outlook for the future due to building construction under way. The company now has under construction power plants aggregating 110,000 hp., an increase of 32 per cent in generating capacity.

THE COLORADO tax commission places the valuation of the Denver Gas and Electric Light Co. at $12,709,600 for 1922. In 1921 the commission named the figures $12,100,000, and when narrating the reason for the increment of $609,600 say that the Denver plant shows the best business in their history; but the fact remains that the state board of equalization has reduced the valuation of the gas company as fixed by the tax commission in sums ranging from $500,000 to $1,000,000 for the past seven years.

The Western Colorado Power Co. was valued at $2,378,630 in 1921 and $2,166,230 in 1922, a reduction of $212,400.

The Colorado Power Co. was reduced half a million dollars in valuation; the 1922 figures are $5,087,480, compared with $5,602,400 in 1921.

ARKANSAS VALLEY RAILWAY, LIGHT AND POWER CO. has changed its name to Southern Colorado Power Co. There is no change in the corporation or officials.

MOBILE (ALA.) ELECTRIC CO. has purchased and is occupying a new two-story and basement concrete and steel office building at Royal and St. Francis streets.

THE SANDUSKY CEMENT CO., Cleveland, O., is installing three 42-in. Fuller-Lehigh screen type mills in its plant at Silica, O., to be used in pulverizing coal for cement kiln and boiler fuel.

THE JOHNS-PRATT CO., of Hartford, has established a Pacific Coast branch office in the Call Building, New Montgomery St., San Francisco, which will be in charge of A. J. Moan.

THE STERLING ICE and Cold Storage Co. has been incorporated for $100,000. The home office is at Sterling, Colo., and the incorporators are H. L. Titus, W. E. Kellogg and W. M. King.

THE WILSON WELDER & METALS CO., INC., 132 King St., New York, N. Y., recently appointed the King-Knight Co., Underwood Bldg., San Francisco, Calif., representatives in central and northern California.

TERRY, COWAN & SMITH, 1733 Walnut St., Kansas City, Mo., on July 1 took over the machinery sales business formerly known as the Merkle Machinery Co. Complete equipment for waterworks, electric light and power plants will be carried.

THE UNITED Machine & Manufacturing Co. announce the appointment of the Hale-Stephan Co., with offices in Cleveland and Detroit, as their representatives in the sale of the Harrington Traveling Grate Stoker and the Industrial Underfeed Stoker.

THE YOUNGLOVE CONSTRUCTION CO., United Bank Bldg., Sioux City, Ia., has been appointed representatives of the Conveyors Corporation of America, 326 W. Madison St., Chicago, Ill., for the sale of American Trolley Carriers in northwestern Iowa and in South Dakota.

SUSQUEHANNA COLLIERIES CO., at Lykens, Pa., has just placed an order for two additional 42-in. Fuller-Lehigh gear driven, screen type mills, which will make a total of six in the Lykens plant, pulverizing exclusively anthracite culm for their power plant, which consists of six 600-hp. and six 500-hp. Edge Moor boilers.

Book Reviews

STEAM POWER PLANT AUXILIARIES AND ACCESSORIES by Terrell Croft, editor; size 5½ by 8 in., 447 pages, 402 illustrations, cloth, New York, 1922.

A large part of the preventable losses in the engine rooms of steam power plants occur in connection with the auxiliary equipment. In general, it may be said that there is but little that can be done to increase the efficiencies of prime movers and that on the whole they give relatively little trouble and are low on maintenance.

Most of the trouble and upkeep expense is due to auxiliaries. In a certain sense, therefore, the auxiliary equipment comprises the most important part of the power plant.

There has been given in this book such data as will enable the plant operator to select and install such auxiliary equipment which will insure the generation of power at the least cost. Information has been given whereby this equipment may be so operated and maintained that the preventable loss will be a minimum and the upkeep as low as possible.

Throughout the text, principles which are presented are explained with descriptive expositions or with worked-out arithmetical examples. At the end of each division there are questions to be answered and in some instances problems to be solved. Detailed solutions of all problems are given in an appendix.

Pumps are first considered because almost every plant requires pumps for its operation. There are sections on pump calculations, direct acting pumps, crank pumps, centrifugal and rotary pumps. Next follows a discussion of boiler feeding apparatus, boiler feed pumps, injectors, traps, etc. After this there are sections on feed water heaters and economizers, then condensers and methods of recooling water. Finally steam piping, live and exhaust steam separators, and steam traps are considered in the light of how they should be selected, installed and maintained.

The book was written largely by various members of the staff of the Terrell Croft Engineering Co., who were specialists in the subject treated.

PETROLEUM, WHERE AND HOW TO FIND IT, by Anthony Blum; size 4¾ by 6½ in., 367 pages, cloth, Chicago, 1922.

Because of the increasing importance of petroleum and its products to our industries and to the nation as a whole and because of the diminishing recoverable supply, the author, himself an operator and oil geologist, has produced this book, largely for the layman. While it discusses the technical features of the industry, its main purpose is to guide the investor in oil properties. It is dedicated to those "Who desire enlightenment on the elements essential to the production of petroleum and to success in the oil business."

The subject is treated in five parts: Geological phase, constructional features, operative phase, commercial phase, and fiscal features.

STEAM HEATING, compiled by the general engineering committee of Warren Webster & Co.; size 8¼ by 10½ in., 367 pages, cloth; Camden, N. J., 1922.

Steam heating has been prepared to meet a demand on the part of heating and ventilating engineers for practical data which can be applied in the design, installation and operation of steam heating systems. As the scope has been closely limited to systems using steam as the heating medium and does not attempt to include the various ramifications of heating and ventilating engineering, it has been possible to cover a great amount of detail information.

Attention has been given to the presentation of tables and charts for the proper selection of sizes and quantities and there is also included sufficient discussion on fundamental principles to produce a balanced text.

Prepared as it was, the manuscript is largely a compilation of facts and data gained from the experience of the company in designing, producing and installing heating appliances.

The book is composed of three parts: Part I, Steam Heating; Part II, Webster Steam Specialties and Application; and Part III, Miscellaneous Useful Tables and Information.

Steam Heating is treated under the heads: Elements of steam heating, data required for steam heating system design, heat transmission, air infiltration, calculation of heat requirements, computing and selecting heating surface, effect of ventilating problems on design of system, proportioning of chimneys, boilers, flow of steam, critical velocities, vacuum pumps and auxiliary equipment and tests for heating efficiency.

Part II deals with the application of various Webster appliances to different heating installations.

The section devoted to heat transmission is particularly complete and presents a wealth of information on heat losses through various types of structures for walls, ceilings and floors. Factors are given in such a form as to be more readily usable than those usually found.

Methods given for calculating heat requirements are concise and readily followed. A typical heat requirement computation sheet is given as an example. With this as a model, it would be almost impossible to go wrong on solving such a problem.

Catalog Notes

TURBO-BLOWERS for gas works are illustrated and discussed in a folder recently issued by Rateau Battu Smoot Co., 90 West St., New York.

AMERICAN NICKEL, its properties and uses, is discussed in Bulletin No. 101 from American Nickel Corporation, Clearfield, Pa.

LINK-BELT CO.'S book No. 444, just issued, contains much interesting information and illustrations on the subject of the new Link-Belt power hoe for the storing and reclaiming of materials.

AN ILLUSTRATED folder relative to pipe fittings and ingenious special connections for spiral, riveted and lap-welded steel pipe, was lately received from American Spiral Pipe Works, W. 14th St. and S. 48th Ave., Chicago.

BULLETIN No. 369 of The Jeffrey Manufacturing Co., Columbus, Ohio, illustrates and describes a new Jeffrey material handling product, The Jeffrey portable belt conveyor, which was built to meet the demand for a light, durable and inexpensive conveyor for loading and unloading coal, coke, cinders, sand, gravel, crushed stone and similar materials, also being used for handling such materials as bricks, tile, small boxes and bags.

REGULATING BOILER FEED WATER is the title of a 20-page booklet just published by the Northern Equipment Co., Erie, Pa. The subject has been treated in an entirely new way, the object being to cover the subject of boiler feed water regulation completely, yet briefly. To accomplish this purpose, free use has been made of a graphical method of presentation: charts showing the effect of feed water regulation on water input, steam output, feed water temperature, etc., also other charts, photographs, etc.